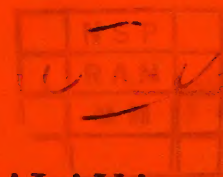


ANNUAL REPORT

1956

RUBBER RESEARCH INSTITUTE OF MALAYA



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Price three dollars

Corrections

1953 Annual Report

Page

- 35 Line 43, for small clones read same clones
- 37 Line 8, for radically read radially
- 40 Line 32, for 2/S/2.d read 2S/2d
- 40 Line 40, for double fourth read double-four
- 65 Line 3 after Table, for sulphate read sulphite

1954 Annual Report

Page

- 28 Line 25, for per tree year read per tree per year
- 30 Line 5, for Pil B4 read Pil B84
- 34 Line 27, for practice in read practice it
- 35 In the tabular matter, the last three columns of figures should be included under the heading '2,4,5-T in diesel oil'

ANNUAL REPORT

1956

RUBBER RESEARCH INSTITUTE OF MALAYA

Printed by The Malaya Publishing House Ltd
for The Rubber Research Institute of Malaya,
Kuala Lumpur, Selangor.

Report of the Board

The constitution of the Board is as prescribed by the R.R.I. Enactment No. 14 of 1934 and the members at 31 December 1956 were:

- a The Director of the Institute—*ex officio*—Chairman
- b The Secretary to the Treasury, Federation of Malaya—(Financial Member appointed by the High Commissioner)
- c The Director of Agriculture, Federation of Malaya—*ex officio*
- d Members appointed by the High Commissioner to represent the interest of small-holders:

The Hon'ble Tuan Haji Sheikh Ahmad bin Sheikh Mustapha,
C.B.E., J.P., M.C.H.

Mr Fong Yeok Seng

- e Members appointed by the High Commissioner from a panel nominated jointly by the Rubber Growers' Association, the United Planting Association of Malaya and the Malayan Estate Owners' Association:

The Hon'ble Mr G. M. Knocker

The Hon'ble Mr J. C. Mathison, O.B.E.

Mr R. A. Coles

Mr A. W. Goode

Mr Gunn Lay Teik, O.B.E.

The appointments under (d) are for three years from 1 September 1955. Of the members under (e) Mr Knocker was re-appointed for three years with effect from 1 September 1956. Mr Arumugam resigned for reasons of ill-health on the expiration of his term of office on 1 September 1956 and Mr Gunn Lay Teik was appointed in his place for three years. The terms of office of Mr Mathison and Mr Coles expired on 1 November 1956 and they were re-appointed for a period of three years from that date. Mr Goode's appointment for three years dates from 1 April 1955. The Chairman of the Board (Mr C. E. T. Mann) returned from home leave and resumed duty on 9 January 1956.

At the close of the year the members of the Board under a, b and c were, respectively: Mr C. E. T. Mann, Mr S. Angus and Mr R. G. Heath.

The Permanent Committee consists of five members of the Board:

The Director of the Institute—*ex officio*—Chairman

The Financial Member—*ex officio*

Three members appointed by the High Commissioner.

At 31 December 1956 the three appointed members were:

The Hon'ble Tuan Haji Sheikh Ahmad

Mr J. C. Mathison

Mr R. G. Heath.

During the year the Board held three statutory meetings and one special meeting; the Permanent Committee met five times.

Policy—The Board has continued to follow its mandate, as written in the R.R.I. of Malaya Enactment of 1934, to undertake 'research into and investigation of all problems and matters relating to rubber and the provision of information relating to the same'.

Following upon the qualified acceptance of plans for continued development and expansion of the work of the Institute, submitted in 1953, the Board recommended in December 1954 that the Industry should consider the advisability of seeking independent advice upon the present and future provision for research and technical services financed by the Malayan Rubber Fund. Proposals to undertake a survey on the lines suggested were considered by the Rubber Producers' Council of the Federation of Malaya and the Council decided to appoint a Committee, under the Chairmanship of Professor G. E. Blackman, Sibthorpe Professor of Agriculture in the University of Oxford, to examine all aspects of research, advisory services and development work for natural rubber undertaken by the Rubber Research Institute, the British Rubber Producers' Research Association and the Natural Rubber Development Board whose work is financed from the Malayan Rubber Fund.

The appointment of the Blackman Committee was announced in January 1956. Professor Blackman made a first visit to Malaya in March 1956, when he made a preliminary survey of the work of the R.R.I., and returned in July with three other members of his Committee for detailed investigation and discussions with representatives of the Industry and the Board and staff of the Institute. The Committee's investigations in Malaya were followed by similar investigations of the work of the B.R.P.R.A. in the United Kingdom and of the N.R.D.B. in the United Kingdom and the U.S.A. At the end of the year it was expected that Professor Blackman would submit the Report of his Committee to the Rubber Producers' Council early in January 1957.

Finance—Approved estimates of total expenditure and revenue together with statements of actual expenditure and revenue, subject to audit, for the year 1956 are shown below:

	Approved estimate \$	Estimated expenditure \$
R.R.I. Headquarters and Laboratories	3,667,053	3,445,000
*R.R.I. Experiment Station Sungei Buloh	890,062	998,500

Revenue—Estimated revenue for the R.R.I. Experiment Station from sales of rubber and planting material, and refund of cesses under the Rubber Industry (Replanting) Ordinances, as at 31 December 1956 is \$898,000.

The relationship between the Board's claims on the Malayan Rubber Fund and those of other bodies financed from the Fund are clearly shown in the brief analysis, presented below, of the accounts of the M.R.F. for the year 1955—published in the Federation of Malaya Government Gazette, No. 2370 of 18 October, 1956.

* It should be noted that the Board receives no contribution from the Malayan Fund towards the operation of the Experiment Station. The R.R.I.E.S. is regarded as a self-supporting unit and all expenditure, including capital expenditure on development of new experimental areas and for replanting, is provided from station revenue. Subject to assistance from the M.R.F. in meeting an overall deficit on any year of operation, annual profits from the Experiment Station are paid into the Malayan Rubber Fund.

Report of the Board

Income and allocations from the Malayan Rubber Fund, 1955—

Allocation as %
total revenue

Income	\$		
Schedule III—cess @ 0.50c/lb from Rubber exported from Federation	6,921,939		
Cess collections Colony of Singapore	17,383		
Interest on investments	80,577		
Interest on bank deposit	10,528		
Total income from cess and investments	<u>7,030,27</u>	..	100
 Expenditure	 \$		
Administration: Controller's Office	18,753	..	0.3
Contribution to the International Rubber Study Group	6,948	..	0.1
Rubber Research Institute of Malaya	3,207,177	..	45.6
British Rubber Producers' Res. Assn.	1,301,361	..	18.5
Natural Rubber Devt. Board	1,419,994	..	20.2
Rubber Producers' Council	103,366	..	1.5
Total expenditure	<u>6,057,579</u>	..	86.2
Balance of Income over expenditure	972,848	..	13.8

Note: In addition to the amount received from the Malayan Rubber Fund the Research and Development organisations received contributions as follows:

R.R.I.M.	\$52,446 from North Borneo and Nigeria
B.R.P.R.A.	£12,264 (sterling) from Ceylon, Brunei and North Borneo
N.R.D.B.	£ 9,847 (sterling) from the Singapore Rubber Association, Brunei and North Borneo

Research Programme and Estimates 1957—The Board approved detailed programmes of work for the year 1957 and estimates of expenditure totalling \$4,244,436 to cover the approved programmes. Approval was subject to any revisions that may be needed in 1957 in the light of recommendations that may be made in the Report of the Blackman Committee and referred to the Board by the Rubber Producers' Council for adoption.

After coordination of the Board's estimates with those of other bodies financed from the Malayan Rubber Fund, the Controller of Rubber approved contribution to the Board of the R.R.I. of \$4,000,000 subject to reconsideration when the Report of the Blackman Committee has been considered by the Industry and action taken upon it.

Staff and conditions of service in the R.R.I.—It has been the policy of the Board since the foundation of the R.R.I.M. in 1926 to offer to all of its employees terms and conditions of service that are approximately equivalent to those offered by the Government of Malaya to men in comparable posts in the public services. Continuation of this policy under the rapidly changing conditions of the post-war years has entailed frequent *ad hoc* revisions by the Board of salary scales and conditions of service. Moreover, since the end of 1953, the Board has found it increasingly difficult to

recruit and to retain qualified men, particularly in the graduate research officer grades. At the end of the year the Board decided to make no further *ad hoc* revisions in its terms of staff employment but to review the entire structure of terms and conditions of service for all staff on receipt of the recommendations of the Blackman Committee as adopted by the Industry. At 31 December, whilst the Institute had a full complement of assistant staff the foreseeable position during 1957 would be that not less than 10 vacant posts on the research and advisory officer establishment of 39 (graduate staff) would remain to be filled.

C. E. T. MANN
Chairman of the Board

Report of the Director

Review of Research and Advisory Work

Research—The general pattern of research work has continued on the basis of a broad division between research on the problems of production of natural rubber by the Botanical, Soils and Pathological Divisions, and research on the problems of treatment, processing and the quality of the product by the Chemical Division (Chemistry and Rubber Technology). Although this division is somewhat arbitrary it works in practice, always provided that there are no obstacles to free contact between research officers in the several divisions. And in this regard, with the development of promising new lines of work in plant physiology, biochemistry and microbiology these valuable contacts, 'at bench level', are developing smoothly.

Cooperation with producers in carrying out research investigations both on estates and smallholdings has also developed notably over the past three years. The pity is that staff shortages have made it difficult for us to take full advantage of the excellent opportunities for advancement such willing cooperation provides; it is hoped that this situation will be remedied soon. Largely resulting from close cooperation with producers in the practical application of the results of original researches carried out at the Institute and at Sungei Buloh, all Divisions record notable advances in major research projects during the year.

In the second vital field for cooperation our contacts with the consuming industry in course of development of new lines of work in the Chemical Division have steadily increased during the year. It is worth recording that several members of the 'Goodwill Delegation' of British Rubber Manufacturers who visited Malaya in 1956 to explain why synthetic rubber was needed in the modern rubber manufacturing industry in the United Kingdom spent some time with the rubber chemists of the R.R.I. A remarkable improvement in our subsequent contacts with rubber manufacturers in the United Kingdom has developed since the personal meetings with their representatives in Malaya, contacts which we believe will develop to their advantage and to ours.

To a lesser extent cooperation with marketing organisations for natural rubber has improved, but it seems doubtful whether the basically divergent viewpoints of the 'market', whose objective is service with profit, and ours which is to render technical service, with quality a first consideration, will ever be closely reconciled.

The planning of new experimental work in all divisions is now generally undertaken by small discussion groups of the research officers concerned, in consultation with the Statistician. The Statistician advises on the most suitable design and lay-out for major laboratory and field experiments and accepts responsibility for the analysis and advice on interpretation of results. During the year the Statistics Section has undertaken the analysis of results of some 150 laboratory and large-scale field trials and submitted reports on each series of experiments. During the year the installation of Powers Samas punched card equipment has facilitated the summarising of experimental records although full operation will be restricted until delivery of the entire installation is completed in 1957.

Advisory services—Based on the numbers of written enquiries received, interviews at headquarters and the Experiment Station, advisory and inspection visits to estates and the increased demand for *Planters' Bulletin*, the volume of advisory work shows approximately a 30 per cent increase in 1956 over 1955. Whilst this in itself is healthy, for it shows that the Institute's work is increasing in value to the producers, there is another and serious side to the picture. The Board has seldom been able to employ

exclusively research officers; each senior officer has been required to undertake a share of the general advisory work in his own Division. Although it is possible by careful administration to ensure that each officer shall have the opportunity to pursue one or more basic research problems, it has generally happened, especially in the postwar period, that the most senior and experienced officers have to spend much of their time on direct advisory work to producers, and in assisting less experienced officers to deal with advisory problems. Absences of senior officers on long leave accentuate the demands for advisory services on those remaining on duty with consequent slowing down of progress in the research field. The Board with the Director and Heads of Divisions have given much thought to the solution of this problem and plans to establish an Estates Advisory Service as a new division of the Institute were under consideration at the end of the year. Another aspect of the same problem is the increasing demand from Estates, and from young Malaysians who wish to enter the industry, for instruction in all branches of rubber planting practice. The Board has also received requests from the Governments of neighbouring territories, Borneo, Sarawak (who contribute to the Malayan Rubber Fund) Siam and Burma (who do not contribute) to provide instructional courses at the Institute and the Experiment Station for young Agricultural Officers and for private students. It has been the Board's policy to assist as far as may be possible, without undue interference with the more important work of the Institute, to meet such requests. However, the increasing pressure, particularly from young Malaysians, for instruction courses is creating a problem that calls for urgent attention. In the Board's view it can be regarded as a proper function of the Institute to provide practical training courses in various aspects of plantation practice but the majority of members do not consider that the R.R.I. Experiment Station is quite the right place for such courses, except in certain specialised fields. This subject will be for further consideration in 1957.

The Smallholders' Advisory Service has extended its work among smallholders through the establishment of the new cadre of Assistant Rubber Instructors instituted in 1954 and 1955, after secondment and subsequent substantive appointment of many of the most experienced Rubber Instructors to the Rubber Industry (Replanting) Board—Fund 'B'. Assistant Rubber Instructors are selected and trained on the R.R.I. Experiment Station by the Senior Staff of the S.H.A.S. and the Management Staff of the Experiment Station.

Publications and library—*Planters' Bulletin* has now firmly established itself as the recognised source of information for the planter on the work of the R.R.I. and of advice on its practical application. The distribution of *Planters' Bulletin* now exceeds 3000 copies per issue of which one third are on a subscription list. Six numbers of the *Bulletin*, issued on 1 January, March, May, July, September and November 1956 were sent to all on the free mailing list and to all subscribers.

Three research Communications to the *Journal* of the R.R.I.M. were prepared, which completed Volume 14.

The Library now holds some 15,000 volumes, but a better indication of its activities is the number of periodicals received regularly; these total about 500. The Library translations service added a further 30 titles, and the special information card index system on rubber was extended to include manufacturing items.

Liaison with cognate organisations—The Institute continued to maintain close contact with the British Rubber Producers' Research Association, the Natural Rubber Development Board and its subsidiary, the Natural Rubber Bureau in Washington. Especial thanks are due to the Natural Rubber Bureau for their efficient assistance in making contact with rubber consumers in the U.S.A. who have shown keen interest in modified forms of natural dry rubber and concentrated latex developed by the Chemical Division of the R.R.I.

During the year the staff of the L.A.C. Research and Advisory Unit, under the control of the London Advisory Committee for Rubber Research (Ceylon and Malaya) has removed by stages to Welwyn and the unit has now been amalgamated with the British Rubber Producers' Research Association. Work at the laboratories of the L.A.C. at the Imperial Institute will be finally wound up early in 1957.

Cooperation with other research organisations for natural rubber in Indonesia, Sumatra (AVROS) and Java (CPV), in Ceylon (RRIC) and Vietnam (IRCI) has been maintained, particularly in regard to exchange of high-yielding hevea planting material and in work on the protection of hevea in the Far East from the dangers of the introduction of South American leaf blight. In the latter connection good liaison is being maintained with the Instituto Agronomico do Norte (IAN) Brazil, and with the Research Division for Horticultural Crops, Plant Introduction Section of the United States Department of Agriculture.

The Board of the R.R.I. continued to be represented on the International Rubber Research Board and International Rubber Development Committee and appropriate senior officers of the Chemical Division on leave during the year in Europe represented the R.R.I. at meetings of the Board and Committee in London, Paris and Delft.

Brief reports from the principal Divisions of the R.R.I., from the Smallholders' Advisory Service and the Manager of the R.R.I. Experiment Station, are presented below.

SOILS DIVISION

Research

Manuring of hevea—Results from field experiments continued to show benefits from fertiliser treatments to rubber trees of all ages. During the first few years, growth of young rubber trees increases with increasing frequency of application of fertilisers, both in replantings and new plantings.

There is further evidence to support the previous finding that soluble and insoluble phosphates (superphosphate and rock phosphate) are equally effective when used for manuring of young replanted rubber. No significant difference was detected between the effects of broadcast and 'pocket' applications of phosphate.

Compost in the planting baskets gave a measurable response in improved growth of plants one year after planting.

Analysis of the combined results of seventeen manuring experiments in mature rubber areas revealed some very interesting information. On inland soils there was a marked response to P in terms of both growth and yield. N also had a beneficial effect on growth and yield, but the effect on yield was greater in the presence than in the absence of K. The N effect on girth increment on the other hand was generally independent of the presence of K. The conclusion drawn on averaging the results of the seventeen trials is that applications of the three major plant nutrients, N, P and K may be required for maximum effect on yield.

In areas on coastal alluvial soils a response to applications of N, in terms of both growth and yield, was established.

Cultivation and ground covers—Young rubber replants had a greater mean height when ground cover was controlled by strip weeding than by circle weeding. Mulching had a beneficial effect in both circle weeded and strip weeded plots. A positive response to mulching was established also in other experiments.

Spraying trials on control of grasses, including 'alang', were continued. Most of the smaller grasses can be controlled effectively by spraying with 'Dowpon' (previously known as 'Dalapon') at the rate of 10 lb in 100 gallons of water per acre. The effect persists much longer than that of sodium arsenite. Preliminary results from recent trials indicate that heavy growth of alang can be checked sufficiently, by one round of spraying with a solution of Dowpon of similar concentration, to allow for subsequent control by wiping with oil. ('Dowpon' is the sodium salt of dichloropropionic acid).

Further trials confirmed that sodium chlorate is particularly effective in controlling *Ischaemum muticum*, commonly known as 'bamboo grass'.

Several new herbicides were tested. None proved as effective as Dowpon for control of grasses, but some gave promise of value in their effect on reducing the emergence of weeds in land cleaned up for establishing nurseries.

Molybdenum applied to *Centrosema pubescens* grown in pots, using three different soil types, significantly increased the molybdenum and nitrogen concentrations in the plant leaves, roots and nodules. Lime added to the soil increased the uptake of molybdenum by the plant both in the presence and absence of added molybdenum. The fixation of atmospheric nitrogen by *Centrosema pubescens* has been demonstrated.

Soil investigations—In laboratory experiments designed to study nitrification in local soils it was shown that addition of lime, equivalent to 4 tons per acre, causes an eventual increase in the rate of free nitrification in the soil after an initial depression. Differences were observed when organic material in the form of chopped leaves of *Pueraria*, *Centrosema*, *Mikania* and 'alang' were mixed with soils. With 'alang' no nitrification was detected over a period of three months. *Pueraria*, *Centrosema* and *Mikania*, in decreasing order, showed increased nitrification after initial periods of nitrogen immobilisation of 3, 2 and 7 weeks respectively.

Plant investigations—Analyses of leaf and bark samples from field manurial trials have shown that, in many respects, analysis of bark gives as good an indication of the plant nutrient status as does analysis of the leaves.

In a sand culture experiment a minute supply of cobalt was observed to benefit the growth and especially the root development of the rubber plant. However, in its absence, no diagnostic visual symptoms were observed.

Large differences in vigour and growth of rubber seedlings may occur as a result of varying the relative supply levels of molybdate, sulphate and calcium ions but without any visual indication of nutrient deficiency. Considerable reduction in growth may result from unfavourable balance of these elements. High sulphate level caused the development of severe molybdenum deficiency symptoms in the leaves.

Rubber seedlings grown in the dark showed no decrease in the rubber concentration per plant even though the plant showed obvious signs of starvation. A clear positive effect of micronutrient supply on the carbohydrate content of the plants, either in the dark or in light, was observed.

In preliminary trials undertaken in collaboration with the Pathology Division to study the effect of mineral nutrient status on the susceptibility of the rubber to bird's eye spot disease, there were indications that the severity of the infection increased significantly as the nitrogen supply to the plant increased.

Advisory Work

No marked change occurred in the general pattern of advisory work although the volume increased by some 25%. Advice on manuring accounted for 30% of advisory letters despatched, and weed eradication came next with 25%. Publication of a note on Dowpon as a weedkiller for control of grasses in the March issue of *Planters' Bulletin* aroused considerable interest and it has since been used on a small scale on several estates.

Points of interest arising from advisory visits to estates were:

- i Greater appreciation of the value of manuring young mature rubber areas.
- ii Increasing number of instances of potassium deficiency were noted, mainly in fully mature trees.
- iii The occurrence of mild symptoms of nitrogen deficiency in young and mature trees grown on coastal alluvial soils.
- iv The frequent occurrence of iron deficiency symptoms in young trees growing on a light, bleached, sandy soil in Perak.
- v The extensive occurrence of manganese deficiency symptoms in young trees growing on a light, bleached, sandy soil in Perak.

BOTANICAL DIVISION

Research

Breeding and selection—Nearly 1,000 new legitimate seedlings were obtained from over 6,000 hand pollinations, representing seven different crosses. Two hundred and fiftysix new clones were made from the legitimate seedlings of 1954 hand pollinated material.

A large scale trial was started at the R.R.I. Experiment Station of 100 clones, including both local and foreign exchange clones and three similar large-scale trials will be established on estates when budwood has been multiplied. This collection is designated the Exchange Clones—1954.

Yield recording continued on the older clone and clonal seedling trials established on Estates and at Sunegi Buloh between 1935 and 1941. The first year of tapping of the large scale trial of clones RRIM 600 to 618 was completed at the Experiment Station.

Tapping was also commenced in some of the post-war estate trials of clones of the '500' and '600' series. Two of the RRIM 600 clones yielded over 900 lb/acre during the first year of commercial tapping, age 6 to 7 years from budding.

Tapping experiments—Periodic change over tapping systems which have been used in experiments to overcome the high incidence of brown bast on certain clones and 'clonal' seedlings without reducing yield appear to show that only by tapping at reduced intensity ($S/2.d/3.67\%$) will the incidence be kept within acceptable limits.

Experiments with high cuts by ladder tapping are showing that when first renewed bark has been tapped out increased yield may be obtained by tapping buddings at a high level. Large clonal differences have been established; for example clones PB 186, Pil B84, Pil A44 and Tjir 1 have given outstanding yields during the first two years of ladder tapping. The yields of unselected seedling trees of similar age showed no increase under high level ladder tapping, probably because of the shorter length of cuts. High cuts on both seedlings and buddings when treated with yield stimulants have given greatly increased yields; this procedure is now used on a wide scale commercially in Malaya.

High yields continue to be recorded in the intensive tapping experiment. Budgrafted trees (9 clones) have been tapped for over 30 months continuously at 200% intensity and seedling trees tapped for eighteen months at the same intensity without apparent ill effects. The effect of yield stimulant combined with this tapping system is now under investigation on trees of different ages.

In yield stimulation experiments our first studies on bark renewal have been completed and have shown that the initial effect of several bark stimulation treatments is lost as time progresses. Tree poisoning with 2,4,5-T appeared promising and the Pathological Division is examining its effect in killing rubber tree roots.

Physiology—Promising progress has been made in the propagation of rubber from cuttings and from callus tissue developed from leaves.

Work continued on the development of practical methods of quantitative determination of growth substances (plant hormones) in hevea bark and leaves.

Ecology—The search for new useful cover plants continued; cover plant trials have been restarted; experiments on storage and viability of cover crop seeds are in progress. Twenty new specimens have been added to the herbarium collection.

Advisory work—Advisory correspondence, which was nearly doubled in 1955, continued to show a further steep rise. Much additional work in this field was due to the examination by our inspectors of prospective seed collection areas in cooperation with Estates, the Department of Agriculture and the Board of Administrators of Government Rubber Replanting Schemes.

Over 180 visits were made to estates, and a special tour lasting six weeks was made to rubber estates and holdings in North Borneo.

The work of examining and testing samples of cover crop seeds greatly increased.

PATHOLOGICAL DIVISION

Research

Root disease—The susceptibility of jungle trees to the root diseases of rubber is being studied because of its bearing on the amount of disease in new plantings. Inoculating their roots with pieces of infected wood has caused some jungle species to develop the disease.

One major experiment on stump poisoning with sodium arsenite is nearing completion. It has not only confirmed the beneficial effect of poisoning any stumps that are left in the ground when replanting, but it has also provided a comparison of different poisoning methods. A new experiment has been started to test 2,4,5-T as an alternative poison to sodium arsenite.

Another experiment which is approaching completion and which again has shown the benefit of stump poisoning (still more of poisoning standing trees) in reducing the incidence of root disease in a replanting, has also revealed how surface timber can spread infection.

Methods of treating the young stand are under investigation, and results of value are expected when the control treatments are opened up for comparison with the others. Elsewhere, tests are being conducted in the hope of finding a better method of killing trees than those now in use.

Other approaches to the root disease problem are being made by observations on the competitive colonisation of dead stumps by the root disease fungi, and on the amount by which the rate of spread of white root disease can be slowed down by preventing

rhizomorph growth; meanwhile, chemical methods of suppressing rhizomorph growth are being sought. A start has been made on a study of the part played by insects in destroying trees and stumps, which are thereby disposed of as possible sources of root disease infection.

The results of a root disease survey on smallholders' replantings, carried out by staff of the Rubber Industry Replanting Board, are being analysed.

Panel diseases—One proprietary material submitted for approval as a mouldy rot fungicide has been tested and found satisfactory at a concentration below the level where bark burning occurs. Tests have also been completed on a series of tar-acid fractions prepared by a commercial producer, as a result of investigations carried out at Long Ashton Research Station on behalf of the R.R.I.M. Certain non-aqueous materials also have been given field trials, with indifferent results.

Leaf diseases—The annual survey of secondary leaf fall in Malaya revealed no unusual features. The most important of the other leaf diseases — bird's eye spot — is being investigated in two ways. Studying the effect of nutrition of the young plants (in cooperation with the Soils Division) has indicated that a higher nitrogen status leads to more disease. Fungicidal applications in the field, using new materials and techniques, have given disappointing results.

Pink disease—A detailed study of pink disease is in progress. The course of the disease is being studied in cases of natural and artificial infection. Observations have been made on spore production, but experimental spore inoculations have not started any infections. A census of infected trees on the Experiment Station has indicated clonal differences in susceptibility to the disease. Clone RRIM 501, which when young is notably susceptible, has been used as an indicator clone in surveying the geographical distribution of the disease, which has been found to be virtually non-existent on coastal alluvial soils.

Pests—The insecticide 'Dieldrin' has been shown to persist extremely well in all soils except peat, treated soil remaining lethal to termites for two years in one experiment, while young rubber trees in the field have been protected for longer periods by both 'Dieldrin' and 'Aldrin'. The same insecticides have not given satisfactory results when tested on a small scale against cockchafer grubs found in isolated outbreaks.

Methods of controlling legume cover crop pests, which have been more prominent of late, are being worked out.

Cross-inoculation tests with eelworm pests of legume covers show that several strains or species of the pests are involved on the different covers.

Inoculation of cover crop seed—A packaged form of *Rhizobium* compost culture has been adopted to replace tubes of agar culture for distribution to estates, after extensive tests had shown them to be no less effective than the latter.

Advisory Work

Root disease, because of its importance, occasions the most enquiries. Apart from requests for identifications, correspondence and visits were mostly concerned with methods of clearing old rubber and with control measures in immature rubber. In addition, some attention has been paid to the economics of root disease control in mature plantings of improved material.

Most of the enquiries about leaf diseases concerned bird's eye spot, which is best treated by complete manuring to encourage recovery of plants. *Gloeosporium* leaf disease is next in importance. Pink disease continues to be the most injurious stem infection, while a branch dieback of a different kind, the cause of which has not yet

been determined with certainty, is found especially on clones RRIM 512 and GI 1. Other cases of branch dieback result from wound infections. A form of injury that is still frequently encountered is due to accidental poisoning by weed-killers, sodium arsenite being the commonest cause because it is so widely employed. Various leaf and stem malformations, bark-bursts and burrs, attract attention but are of little consequence. Lightning damage is another non-parasitic injury commonly met with but not always recognised; it can cause considerable damage and loss of trees.

Among pests, cockchafer grubs which destroy the roots of young plants have become more prominent during the year, but they still cannot be described as serious pests.

Various insects attack the leaves of young plants, the mealy bugs and scale insects attracting the most attention. More damage is done by the larger (mammal) pests in young plantations near jungle.

Towards the end of the year under review there were some locally severe outbreaks of pests of creeping legume cover plants.

CHEMICAL DIVISION

Research

The latex concentrate producer will be interested in the further studies of micro-organisms in latex, which show that contrary to earlier expectations, the count of viable bacteria present in a given latex is not always an indication of future behaviour. Thus putrefaction, as shown by volatile fatty acid (VFA) formation, is now known to occur in latices which are nearly sterile. At present the work is directed towards estimating the total cells present, representing both living and dead organisms, since it is possible that enzymes from dead cells may be responsible for some of the undesirable changes that occur in latex on storage. All our findings serve to emphasise the need for great cleanliness in both field and factory in order to keep bacterial infection at a minimum.

Advances in the preservation of latex have been made, particularly in regard to concentrates prepared with low concentration of ammonia. A method of inhibiting VFA formation, which employs enzyme poisoners, has been discovered and patent protection sought.

Small surveys in respect of technical properties, were made of Malayan No. 1 sheet and crepe rubber, in connection with specifications proposed by the American Society for Testing Materials. Significant differences between rubbers collected from different arbitrary groups of estates indicate that much care is required in planning a survey designed to give an accurate picture of the characteristics of rubber produced in Malaya and the proposed A.S.T.M. specifications will need much closer study.

Investigations on dry rubber have demonstrated some interesting features connected with the heating of rubber under dry and wet conditions, which it is hoped will ultimately prove of value in designing improved drying houses.

Considerable interest has been shown by manufacturers in the new rubber which has superior processing qualities, (SP rubber). During the year one company produced 54 tons of SP crepe on a commercial scale and towards the end of the year the R.R.I. Experiment Station factory produced some 15 tons of SP sheet.

Practical work on rubber lignin masterbatch has now been suspended. Comparisons of a continuous and a batch method of preparation on a hundredweight scale have been made and costs of production are now being assessed from the data obtained.

It is proposed to submit a report detailing cost of production and technical behaviour to manufacturers, and to seek their opinion on the potential value of the material for industrial use.

Other investigations in hand include seasonal variation in latex, maturation of latex concentrates, collection and examination of latex under sterile conditions, certain enzyme systems in latex, dirt content of Malayan rubbers, preparation of graft polymers from natural rubber under local conditions, cheaper methods of producing SP rubbers, and production of lower grade rubbers with SP characteristics.

The Division has continued to cooperate with other research institutes under the aegis of the International Rubber Research Board, having prepared papers and comments for discussion at the July and November meetings in Europe, which were attended by a member of the staff whilst on leave. Liaison has been maintained with the British Standards Institution and the American Society for Testing Materials on developing test procedures for dry rubber and latex.

Advisory Work

The largest number of enquiries were concerned with latex concentrate production and much work has been carried out in cooperation with estate factories to develop cleaner methods of working, particularly those involving the use of bactericidal rinses.

In dry rubber preparation chief interest has been shown in redesigning and improving factory layout and plant, and in the use of oil-fired burners for drying sheet and crepe rubber. Trials at the Sungei Buloh Factory are indicating the possibility of using products of combustion for direct heating instead of employing the customary heat exchanger.

Many enquiries have been received on crepe rubber, which commands a high premium, requesting advice on overcoming defects such as spots and fungal infection, ply adhesion in sole crepe, and use of the R.R.I. bleaching agent.

About 80 tons of cyclised rubber were produced commercially during the year, checks on quality control being made in our laboratories.

The output of rubber examined for technical classification decreased slightly during 1956; some 100 estates continued to call upon R.R.I. testing facilities. A small tonnage of rubber from packing houses was classified, but none from remilling factories. Consumer requirements were primarily for 'yellow' (middle class) rubber, with a small amount of 'blue'; very little interest was shown in 'red' rubber.

SMALLHOLDERS' ADVISORY SERVICE

Replanting and new planting—An important task of Rubber Instructors is to advise on control of root disease in replantings. Success depends solely on persuasion since it has not to-date been possible to propose action which can be made compulsory by the Replanting Boards.

Spraying trials of oil-based herbicides for control of lalang have been relatively unsuccessful, mainly because labourers and supervisors have little experience of spraying techniques and because of wet weather. Steps are being taken to establish a technique which can be readily demonstrated to smallholders.

In general we have been able to strengthen our service in districts where new planting is the most important subject for advice to smallholders. The total amount of new planting, over 13,000 acres, increased by more than 50%, and approximately 87% was done with clonal seedlings, again a higher proportion. Perak and Pahang were the main centres.

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The amount of budding recorded on new plantings was 2,500 acres, slightly lower than in 1955. There appears to be a growing appreciation of the merits of budgrafted trees amongst the most progressive smallholders which can be traced to experience in tapping young rubber areas. Instances of clonal seedlings being budgrafted are increasing.

Production—The number of young areas being opened for tapping is steadily rising and an increasing amount of Rubber Instructors' time must be devoted to advising smallholders on opening trees for tapping and on conservative tapping.

Processing—Records obtained on the quantity of smallholders' latex collected for concentration show a drop of 40% on the 1955 figure, but that collected for sheet manufacture in central factories has shown a considerable increase, so that the quantity collected for both purposes is in the region of 5,500 tons in comparison with 6,000 tons in 1955.

Instruction courses and information—Training for smallholders was provided from time to time at our Experiment Station and a total of 104 smallholders attended three courses each lasting four weeks during the main planting season, which is an encouraging demand in view of the fact that each trainee has to find, on an average, about \$100/- to cover transport expenses and food. Four Rubber Instructors have conducted courses for young people in their areas. Classes are held on one day a week over a period of not less than six months. Other Rubber Instructors have been responsible for the training in rubber which forms part of courses held at Agricultural Stations.

The establishment of an R.R.I. Instruction Centre for Smallholders in Malacca has proceeded during the year. Land has been purchased and a start made on erection of the necessary buildings.

Our mobile cinema unit has been available to all Rubber Instructors during the year. It has been away on tour during 177 days and given a total 140 screenings of R.R.I. films. It has also been used to support training courses at the Experiment Station and elsewhere.

A booklet on 'Good Tapping' is in course of printing in English, Jawi and Chinese, and a Rumi edition of 'Replanting on Smallholdings' is also with the printers. Leaflets have been published on various aspects of planting rubber.

A report was completed, and duplicated for limited distribution, on the marketing of smallholders' rubber with special reference to the 'first buyer' level.

R.R.I. EXPERIMENT STATION

Details of the acreage statement at 31 December were:

	Acres
Mature rubber in tapping	1,146.00
Immature rubber	1,027.75
Nurseries	31.25
Smallholders seed garden	
Mature in tapping	10.50 acres
Immature (24 acres budwood nurseries interplanted)	191.75 acres
Building sites	87.00
Reserve land (165 acres in course of felling)	484.75
	2,979.00

Mature area—The policy of maintenance and upkeep in mature areas remained unchanged, natural covers were slashed twice during the year and regular weeding rounds were maintained. Fertilisers were applied to 60 acres.

Tapping was commenced in 99.5 acres of young rubber; 134.5 acres of old rubber, scheduled for replanting between 1956 and 1958, were under intensive tapping for most of the year.

Yield stimulants were used over a further 187 acres, in most cases on new cuts in virgin bark above renewed bark.

A total crop of 1,052,626 lb of rubber was harvested, giving an average yield of 920 lb per acre, the bulk of which was manufactured as latex concentrate.

New clearing—Steeply undulating reserve land, 84 acres, was felled, cleared, terraced and planted. Twenty acres were planted with the 1954 and 1956 hand pollinated seedling stumps and basket plants whilst the balance was planted with germinated seed for budding in 1957.

Felling of an additional 165 acres of jungle land, scheduled to be planted in 1957 started in November.

Replanting—101.75 acres of old rubber were felled or poisoned and replanted with seedling stumps for budgrafting later. Most of this area has been allotted to cover plant and cultivation experiments.

Immature areas—Budgrafting with 100 of the 1954 exchange clones was done in a clone trial over 100 acres of the 1956 clearing and these clones were also budgrafted in nurseries for multiplication of budwood. A small scale trial on 22 acres of the same clearing was budgrafted with 256 new clones made from the 1954 hand pollinated seedlings.

Fertilisers were applied to 445 acres of young rubber.

All immature rubber came under regular inspection for root disease. Prophylactic treatment against termites with Aldrex 1:400 was completed over 466 acres, and is being extended to all immature rubber. The incidence of pink disease was fairly high.

Throughout most of the older immature rubber, the planting rows were sprayed periodically with sodium arsenite, whilst in younger areas manual strip weeding of planting rows and selective weeding between rows were continued. Upright covers in the interrows were slashed periodically.

Planting material—Clonal seeds, and budwood amounting to some 9,700 yards were distributed to estates for commercial and experimental planting.

The Smallholders' nursery supplied to smallholders 66,600 yards of budwood and 23,800 seed were collected from Garden B and despatched to the Department of Agriculture for use in the Replanting Board nurseries.

General

Training courses were held at the Station for estate senior conductors, prospective R.I.(R.)B. subordinate staff and Rubber Instructors, Smallholders, and various categories of students.

Over 500 visitors attended the Station during the year.

C. E. T. MANN
Director

Soils Division

The Head of Division was absent on home leave from April to November. Dr E. W. Bolle-Jones, Dr G. A. Watson, Mr G. M. F. Grundy, Mr V. R. Mallikarjuneswara and Mr M. M. Guha were on duty throughout the year. Mr G. M. F. Grundy left the service of the Institute after completing a four years tour at the end of December.

A paper entitled 'A Glasshouse Suitable for Investigations on Plants Grown in the Tropics' was published in the *Empire Journal of Experimental Agriculture*. Other papers prepared are: 'A Magnesium-Manganese Interrelationship in the Mineral Nutrition of *Hevea brasiliensis*'; 'Visual Symptoms of Mineral Deficiencies of *Hevea brasiliensis*' and 'Cover Plants in Rubber Cultivation'. Short papers on the following subjects were published in the *Planters' Bulletin*: A New Weedkiller for Control of Grasses (Dowpon); Sodium Chlorate as a Weedkiller; Methods of Application of Fertilisers; Fertiliser Nomenclature; Soil Analyses; Zinc Deficiency; Mulching; Water Conservation.

As part of the training scheme for Smallholders' Rubber Instructors and for Senior Estate Conductors attending courses of instruction at the Experiment Station, the Soils Chemist (Mr Grundy) gave courses of lectures on soil topics. He also gave a lecture to members of the South Johore Branch of the Incorporated Society of Planters at Johore Bahru.

The usual assistance was given to the Technical Education Scheme of the Incorporated Society of Planters by setting questions and marking papers for the soils section of the Agricultural Science examinations held in February and August.

RESEARCH

MANURING OF HEVEA

Growth measurements were recorded in 46 manuring experiments 9 of which are in immature rubber areas and the remainder in mature areas. Yield records were obtained from 36 experiments.

Effect of fertilisers on growth—In a new planting on a light sandy soil, height measurements of plants recorded at 15 months after planting showed a response to manuring with a complete fertiliser mixture amounting to a mean increase of 7 inches in height with six monthly applications and 13 inches with 3 monthly treatments. In the same experiment 10 lb of cowdung mixed with the soil in the planting hole before planting had no significant beneficial effect on growth.

Results from other experiments in progress showed similar increased effect due to increasing frequency or level of fertiliser application during the first few years after planting. In one replanted area, height measurements recorded during the first year after planting, and again at ten months after budding in the field, showed that the benefit derived from increasing the frequency of application was due mainly to nitrogen. In this area, phosphorus applied in the planting hole would appear to have been adequate to satisfy the requirements of young plants in the initial period of growth, while no response to potassium was detected. In another experiment started at fifteen months after budding in the field (clone RRIM 501), applications of nitrogen,

phosphorus and potassium produced a marked effect on girth increment over the subsequent period of two years. In one section of the field the fertilisers were applied at three different levels (0, 1, 2) at six monthly intervals, and in another section they were applied at three different frequencies (1) once a year, (2) once every six months and (3) once every 3 months. In both areas there was a response to treatment with each of the three nutrient elements N, P and K, and the effects increased with increasing levels or increasing frequency of application.

Significant differences between the effects of superphosphate and rock phosphate on growth of young rubber plants were not established up to four years after commencement of treatment with the phosphatic fertilisers, and there was no consistent difference between the effects produced by 'pocket' and broadcast methods of application.

In regard to mature rubber trees in production, conclusions drawn from analysis of combined data from 17 manuring experiments are of interest. Averaging the effects of fertilisers on girth increments over a six year period following the commencement of a biennial manuring programme, the only notable effects are due to nitrogen, significant at the 10% level, and amounting to an increase in girth of 0.02 inch per tree per annum, and a very significant phosphate effect amounting to 0.03 inch per tree per annum. The effects of both nutrient elements increase steadily from the first to the sixth year when the average effects of N and P are 0.05 and 0.06 inch per tree respectively. Application of potassium had no detectable beneficial effect, but there is evidence to suggest that an NK interaction effect may be developing. In the first five years of recording, the nitrogen effect on girth increment is generally found to be independent of the presence of potassium, but in the sixth year the nitrogen effect in the presence of potassium is 0.08 inch per tree, whereas the nitrogen effect in the absence of potassium is only 0.01 inch per tree.

Similar observations were made when more recent data from individual experiments were examined separately. A positive response in terms of girth increments over a one year period, either to nitrogen or phosphorus, was established in 19 out of 26 experiments.

Effect of fertilisers on yield—The results of analysis of combined data from 17 experiments show that responses to fertiliser treatments in terms of yield are due mainly to nitrogen in the presence of potassium, and to phosphate. This conclusion is based on analysis of records obtained over four years corresponding with the period from about two to six years after commencement of a manuring programme providing for three biennial applications. The mean percentage response to phosphate, over the four years, is about 2% per annum. The mean effect due to nitrogen, estimated as +0.019 tahils per tree per tapping or $3\frac{1}{2}\%$, is not significant, but the nitrogen effect in the presence of potassium (i.e. N and NK) is +0.036 and is significant, whereas the nitrogen effect in the absence of potassium (i.e. N -NK) is -0.016 and is not significant. Interaction of nitrogen with phosphate is not established.

Judged on these results it would appear that the most effective treatment for mature rubber trees on inland soil types is one that provides for application of nitrogen, phosphorus and potassium. On coastal alluvial soils, however, there is little or no response to phosphate and the pattern of response to nitrogen is not quite so clear as in the trials on inland soils. There is some indication of a response to nitrogen alone in the coastal alluvial areas, although here also the effect may be enhanced when the nitrogen is applied with potassium.

It is to be noted that the results reported above are based on records covering only a short period soon after commencement of the manuring programme. At this early stage the magnitude of the effects is small, but it is of interest to note that the mean effect of phosphorus on girth increments increased steadily, averaging 12% in the sixth

year of recording. Similarly, the average response to nitrogen in the presence of potassium, in terms of both yield and growth, increased steadily from the first to the final year of recording. It is evident that effects are developing and larger responses can be expected. Records obtained subsequently from individual experiments have been examined separately during the year and increases in yield of over 20% have been recorded in some of them. A positive response to nitrogen was established with confidence in 4 trials while 6 trials showed a response to phosphate. Where the fertilisers are tested at different levels of application there is generally an increased effect with increasing levels.

CULTIVATION AND GROUND COVER

Weed eradication—Spraying trials on the control of grasses were continued. It was confirmed that sodium chlorate was markedly more effective than sodium arsenite or sodium trichloroacetate for control of the grass *Ischaemum muticum*. This is worthy of note since experience has shown that for control of most of the other common grasses found in rubber areas, sodium arsenite is generally more effective than sodium chlorate. After spraying with sodium chlorate at the rate of 15 lb of the salt per acre, aerial growth of *Ischaemum muticum* was completely killed and there was no growth for a period of at least four months. Equally good results were obtained by spraying with a solution of Dowpon (sodium salt of 2,2-dichloropropionic acid) at the rate of 10 lb per acre.

For the control of *Hemigynnia fusca* (*Panicum nodosum*) Dowpon applied at the rate of 10 lb per acre was more effective than sodium chlorate (25 lb) which, in turn, was more effective than sodium arsenite (15 lb) or sodium trichloroacetate (20 lb). Shell Lalang Oil (100 gallons/acre) was least effective. The effects of Dowpon and sodium chlorate sprays were still discernible six months after spraying.

When sprayed on the grass *Axonopus compressus* solutions of the diethylacetamide derivatives C.D.A.A. and C.D.E.A., and the dimethylurea derivative C.M.U. each at the rate of 9 lb per acre produced no noticeable effect whereas Dowpon and sodium chlorate were very effective when applied at rates of 10 and 25 lb per acre respectively.

Further tests were carried out to examine the possibility of eradicating lalang (*Imperata cylindrica*) by spraying with Dowpon. In preliminary trials it was shown that no advantage was gained by slashing the lalang and allowing new growth to reach a height of twelve to eighteen inches before spraying. It was found that better herbicidal effects were obtained when the solution was sprayed directly on to unslashed lalang. In a series of trials using solutions of Dowpon of varying concentrations good results were obtained even with the lower rates of application. It is considered that, provided climatic conditions are right at the time of spraying, standing lalang can be eradicated successfully by spraying once with Dowpon at the rate of 10 lb per acre followed by rounds of oil wiping starting at about four months after spraying. To allow for normal variability in density of growth of the weed, standard of work and climatic conditions at time of spraying, an application at the rate of 15 lb per acre is recommended for eradication of lalang on estates or smallholdings.

Trials designed to determine whether the use of Dowpon as a weedkiller has any harmful effects on young rubber trees were continued. In earlier trials in areas carrying stands of 5 and 7 years old trees (clones RRIM 501 and G11), no undesirable effects were observed when Dowpon was sprayed on the ground along planting rows at rates ranging up to 50 lb per acre. No harmful effects, either on bark or foliage, were observed when stems of two year old seedlings were sprayed (up to twelve inches above ground level) with a solution of Dowpon equivalent to a concentration of 15 lb in 100 gallons of water. However, in view of reports received of damage caused to

young budded plants in other areas the trials were repeated with a larger variety of clones and with younger trees. It was found that some clones are more susceptible than others; among the most susceptible is clone LCB 1320, while the less susceptible clones include PR 107 and RRIM 501. Severe defoliation and terminal dieback of shoots can occur when quantities at the rate of 30 lb per acre or more are applied along planting rows in areas where the more susceptible clones are growing. There is little risk with rates of application that would be recommended for control of weeds in the field i.e. 10 or 15 lb per acre. Regarding nurseries, two year old seedlings spaced at distances of 2 x 3 feet showed slight toxic effects when the ground was sprayed at the rate of 15 lb per acre. For spraying weeds in nurseries Dowpon must be used with caution.

Recent trials have not confirmed earlier observations which suggested that Dowpon had a selective action on grasses but little effect on the leguminous creeper *Pueraria javanica*. When sprayed on a mixture of grasses and the leguminous cover plant the effect on grasses was greater initially, but observations made at six months after spraying showed that the legume also was killed by Dowpon and *Mikania scandens* invaded the sprayed areas.

Control of ground cover and mulching—In trials comparing methods of controlling the leguminous ground cover in a replanted area, it was established that strip weeding along planting rows provided better growing conditions than circle weeding for young rubber plants during the first year of growth. Mean height of plants at one year after planting was nine inches greater in the strip weeding areas than in the circle weeded plots. Mulching with lalang had a beneficial effect in both circle weeded and strip weeded plots.

Various procedures for control of mixed herbaceous ground cover (mainly indigenous growths) along planting rows were compared. The treatments, which include strip weeding with and without mulching, control by spraying with sodium arsenite with and without addition of sulphate of ammonia to the solution, and no control, were commenced at about one year after budding (clone PR 107). It was found that the rate of girthing of the young trees was significantly greater in plots where the treatment applied combined mulching with strip weeding up to 2½ years after budding, after which time there was no significant difference judged on girth increments over six monthly periods. In this case the increase in rate of growth was due mainly to mulching since the remaining treatments did not differ significantly in their effects.

In another experiment designed to assess the effects of different types of mulching material it was found that cuttings of *Mikania scandens* provide a more effective mulch than cuttings of other mixed indigenous growths or lalang. The mulching treatments commenced at two years after budding and mulching with *Mikania scandens* continued to have a beneficial effect on growth of the young trees up to 4 years after planting with budded stumps, while the rate of girthing in plots where the other mulching materials were used was not significantly greater than in the unmulched plots.

Nutrition of leguminous ground cover—Investigations were carried out, by means of pot experiments, to study the effects of soil pH and molybdenum level on growth of *Centrosema pubescens*. The pH values of each of three different soil types varied slightly in the range 4.5 to 5.0 and varying amounts of lime were applied to give two other values (6.0 and 7.0). Sodium molybdate, equivalent to a dressing of 1 lb per acre, was applied to half the pots. The main results of interest were that the application of molybdenum to the soil increased the molybdenum content of leaf, root and nodule material in all three soils at all three pH values. This treatment also increased the nitrogen content of leaf, root and nodule material at the lowest pH level (4.5 – 5.0) but not at the two higher levels. The application of lime increased the molybdenum

content of nodules and leaf, both in the presence and absence of applied molybdenum, while it resulted in an increase in nitrogen content in the absence, but not in the presence, of applied molybdenum. It would appear that the application of lime made conditions favourable for increased uptake of molybdenum and this effect in turn resulted in an increased nitrogen content of the plant. In general, the weight of leaf material was increased by the application of lime.

SOIL INVESTIGATIONS

Nitrogen balance of Malayan soils—A lysimeter experiment was carried out in which *Centrosema pubescens* and *Mikania scandens* were grown in a medium loam soil derived from granite (Rengam series). The total number of lysimeters included others where no cover was established and the soil remained bare. Nitrogen was applied in the form of urea, ammonium sulphate and sodium nitrate, each at two levels i.e. nil and an application equivalent to 4 cwt per acre of ammonium sulphate. *Centrosema pubescens* maintained vigorous growth but the growth of *Mikania scandens* was extremely poor in the absence of applied nitrogen. The total nitrogen recovered from the leachates and in all plant material was determined. The recovery from lysimeters with *Mikania scandens* did not differ significantly from those with bare soil, whereas the total nitrogen recovered from lysimeters containing *Centrosema pubescens* was significantly higher than either of the other two. This excess of nitrogen averaged over one gram per lysimeter; it is taken to be the nitrogen fixed by the legume and is estimated to be equivalent to 143 lb of nitrogen per acre for treatments involving the application of nitrogenous fertilisers and 209 lb per acre when no fertiliser was applied.

Nitrification studies—Three techniques have been adopted for the study of nitrification in local soils, namely, the Lees and Quastel perfusion method, the standard bottle incubation method and a tube-leaching method developed by Iowa State University. In preliminary tests carried out it was shown that nitrification occurred in the surface layer (0–3 inches) of a loam soil derived from sandstone obtained from a rubber area at the R.R.I. Experiment Station, but not in the subsoil (12 inches–30 inches).

The results of an investigation to study the effect of added ammonium sulphate and calcium carbonate on nitrification in one soil sample showed that over a period of three months nearly 25 mg of soil nitrogen per 100 g of the untreated soil was nitrified, the rate of nitrification remaining steady for the first 40 days without any lag period, and then decreasing. The addition to the soil of calcium carbonate in amounts equivalent to 133 lb per acre had no effect on the rate of nitrification nor on the total amount of nitrate nitrogen produced, but the addition of amounts equivalent to 4 and 9 tons per acre depressed nitrification for an initial period of three weeks and thereafter caused an increase in the rate and amount of nitrification. Addition of ammonium sulphate in amounts equivalent to 4.5 cwt per acre had no appreciable effect either on the total amount of nitrogen nitrified or on the rate of nitrification, both in the presence and absence of added calcium carbonate.

Powdered stem and leaf materials of *Pueraria phaseoloides*, *Centrosema pubescens*, *Mikania scandens* and lalang (*Imperata cylindrica*) were mixed with soil in the ratio or 1:10 and nitrification was studied by the bottle-incubation method. Results showed that no nitrification occurred until after 20, 12 and 50 days in the case of *Pueraria*, *Centrosema* and *Mikania* respectively. In the case of lalang, production of nitrate nitrogen was not detected even within three months. Making a tentative allowance for the nitrification of soil nitrogen in the presence of these plant materials it is estimated that the proportions of plant nitrogen nitrified were:

Pueraria phaseoloides (3.44% N) — 24.4% of the nitrogen nitrified in about 45 days.

Centrosema pubescens (3.53% N) — 22.3% of the nitrogen nitrified in about 85 days.

Mikania scandens (2.44% N) — 16.5% of the nitrogen nitrified in about 85 days.

Production of ammonium nitrogen (ammonification) from organic material was found to proceed during the initial period when no nitrification occurred. With the start of nitrification, however, the content of ammonium nitrogen gradually decreased.

A loss of nitrate nitrogen was found to occur under conditions of water-saturation. Samples representing three main soil types were mixed with water in the proportion of 1 part soil to 2 parts water with and without the addition of nitrate nitrogen. These were incubated for 2, 24 and 48 hours at room temperature. Considerable loss of nitrate nitrogen was observed in all three soils after 24 hours, and more so after 48 hours. The complete inhibition of this loss by the addition of toluene indicates that the denitrification was entirely due to the activities of soil micro-organisms. It was observed that loss of nitrate nitrogen in these conditions was not accompanied by an increase in ammonium nitrogen.

PLANT INVESTIGATIONS

Methods and techniques—Much time was devoted to developing suitable methods for estimation of potassium and calcium by the flame photometric procedure using the Beckman spectrophotometer with flame attachment. The new procedures worked out have considerably reduced the time required for analysis of plant tissues.

A satisfactory colorimetric method was developed for the estimation of cobalt in plant material. The concentration usually found in rubber laminae is small, of the order of about 0.2 p.p.m. of dry matter, whereas that found in the roots is several times greater.

Attention was given also to methods of estimating organic constituents of plant material. Methods have been developed for the estimation of (1) fatty oils in rubber seeds and seed residues, and (2) carbohydrates (hydrolysable carbohydrates as well as the crude fibre fraction) in plant material.

Further work on comparison of leaf and bark analysis for assessing the mineral nutrient status of rubber trees tend to confirm earlier results suggesting that, in many respects, analysis of bark gives as good an indication of plant nutrient status as does that of the leaves.

POT-SAND-CULTURE EXPERIMENTS

Effect of macro-nutrient element status on production and concentration of rubber in stems of young seedlings—Some indirect evidence to show that stem rubber concentration varied with stem phosphorus concentration was obtained from results of an experiment described in an earlier report (*Annual Report 1955*) in which it was shown that, as the copper supply was increased, the stem concentration of phosphorus decreased. This decrease was accompanied by a decrease in the concentration of rubber found in the stem.

A simple experiment designed to study the direct effect of increasing phosphorus levels on stem rubber concentration was initiated. The results to date confirm that increased phosphorus supply increases the concentration of rubber in the stems during

the earlier stages of development of the young seedlings (up to 3 months) but as the plants grow older this beneficial effect of phosphorus on rubber concentration becomes less marked.

Effect of micro-nutrient element status on growth, mineral composition and rubber formation—Symptoms of iron, manganese, boron, copper and zinc deficiencies have been produced in young rubber seedlings grown in sand culture and a full description with colour illustration of these and other symptoms has been prepared for publication. It has been difficult to interpret the symptoms produced under a condition of molybdenum deficiency. It was found that the visible effects of the deficiency were very slight when a large proportion of the nutrient nitrogen was supplied in the form of ammonium salts. When the nitrogen was given mainly as nitrate salts, a marked diminution of growth was exhibited by the molybdenum deficient plants and the molybdenum concentrations in laminae, stems and roots were found to be about 0.07, 0.04, and 0.04 p.p.m. respectively, as opposed to plants supplied with molybdenum having corresponding values of 1.5, 0.5 and 1.2 p.p.m. Tip and marginal scorching was observed in the very pale midstem leaves but as iron deficiency effects were also present a correct assessment of the true nature of molybdenum deficiency symptoms was not possible.

An experiment to investigate the requirement of the rubber plant for cobalt was initiated towards the end of 1955. No direct proof exists to show that this element is essential for growth of higher plants but there is circumstantial evidence which suggest that it may be required. Cobalt was supplied at nil, normal (0.005 p.p.m.) and high (0.25 p.p.m.) levels to PB 86 seedlings grown in sand for a period of one year.

Although symptoms definitely attributable to cobalt deficiency were not recorded, height, girth measurements and dry weight of root of plants grown at the normal level were larger than either those at the nil or high level of cobalt supply. The absolute cobalt content of the plants increased with time; the rate of increase was much smaller for those plants grown in the absence of cobalt which, at the end of the experiment, contained no more than 10 micrograms of cobalt per plant whereas those receiving the normal level of cobalt contained approximately 250 micrograms. The concentrations of cobalt in the laminae were 0.02, 0.36, 4.42 p.p.m. for plants grown at nil, normal and high levels of cobalt respectively. At the levels supplied, cobalt did not affect the concentrations of rubber, chlorophyll, nitrogen, phosphorus, magnesium or potassium in the tissues.

Relative requirement for different nutrients and effect of varying nutrient balance on growth and metabolism of the rubber plant—The experiment designed to study the interrelationships between molybdenum, sulphur and calcium was continued and is of interest in that it clearly indicates that large differences in plant vigour and growth may result without any visual indication of specific nutrient deficiencies. Observations made showed that considerable reduction in growth may occur due to an unfavourable balance of the three nutrient elements under test. High sulphur level caused the development of severe molybdenum deficiency symptoms in the leaves. A detailed discussion of the results will be published in a separate report.

Mineral nutrition in relation to diseases of the rubber tree—In an experiment designed to study the effect of varying levels of nitrogen supply on the severity of attack by *Helminthosporium heveae*, marked differences in growth and mineral status of the plants as a result of treatment were recorded. The severity of attack by the fungus, when assessed in terms of lesion to leaflet ratio, increased significantly as the nitrogen supply to the plant increased.

Effect of mineral nutrition on stem anatomy—As previously reported (Annual Report 1955) the concentration of calcium oxalate crystals in the stem sometimes varied according to the nutrient status of the plant. Further investigation showed that the green rather than the brown (lower) portions of the stems of young seedlings gave a more sensitive index of this variation. The stem concentration of oxalic acid was greater in plants fed with nitrogen in the form of nitrate than in those supplied with nitrogen as ammonium salts, and the concentration diminished as the proportion of ammonium ions in the nutrient solution increased. In general, it seemed that retardation of growth due to deficiency of essential nutrient elements was accompanied by an increase in the amount of oxalic acid found in the stems; the most notable exception were calcium deficient plants which contained a very small amount of oxalic acid in the stems.

ADVISORY

The general pattern of advisory work was much the same as in previous years. The statistics relating to advisory correspondence, visits to estates and interviews at the Institute may be summarised as follows:

Letters and reports despatched ..	537
Visits to estates	64
Interviews at the Institute ..	105

The number of advisory letters despatched during the year was about 60% greater than in the previous year. This increase was accounted for mainly by the large number of enquiries concerning Dowpon following publication of a note on this new weed-killer early in the year, and by the greatly increased number of soil and leaf samples received for examination and analysis. Requests for advice on manuring of immature and young mature rubber increased by 14% and, as in previous years, this was the most important subject dealt with in advisory correspondence amounting to 30% of the enquiries answered. Weed eradication came next in order of frequency amounting to 25% of letters despatched. No important new trends in planting practice were noted except that there was some evidence of a greater appreciation of the value of mulching in newly planted or replanted areas and of the value of manuring of young, high yielding mature rubber areas. Other points of interest noted in the course of visiting estates for advisory purposes were (1) the increasing number of instances of potassium deficiency observed, mainly in fully grown trees, and (2) the occurrence of mild symptoms of nitrogen deficiency in young and mature rubber growing on coastal alluvial soils, a group of soils which has hitherto been regarded as being unresponsive to fertiliser treatment. Recent results from manuring experiments on these coastal alluvial soils, however, have shown that in some areas the trees do respond to treatment with nitrogenous fertilisers.

Symptoms shown by rubber plants when one or other of the trace elements is deficient have been developed and can now be identified. Except for iron and manganese, no symptoms of trace element deficiency have been observed in the field. The frequent occurrence of iron deficiency symptoms in young rubber plants has been

noted, but in all cases confined to relatively small scattered patches on light, highly leached soils. Manganese deficiency symptoms in a large number of trees have been observed in only two areas so far but symptoms indicating deficiencies of copper, zinc, boron or molybdenum have not yet been observed in the field. Judged on field observations to date there is nothing to indicate that trace element deficiency is a major problem in rubber areas of Malaya.

G. OWEN
Head of Soils Division

Botanical Division

Mr C. W. Brookson, Mr P. de Jonge, Mr J. M. Ross and Mr V. K. Bhaskaran Nair were on duty throughout the year. Dr E. D. C. Baptist resigned as Head of the Division on 9 February after nearly twenty years service to become Director of the Rubber Research Institute of Ceylon. Mr C. W. Brookson acted until 31 May and as from 1 June he was confirmed as Head of Botanical Division. Dr J. S. Lowe resigned after completion of his first tour on 18 February. Dr P. R. Wycherley commenced his long leave with effect from 14 July. Mr T. V. Vaidyanathan commenced his long leave on 24 December. Mrs Margaret Pond B. S. was appointed to a part-time temporary post on 1 May, and Dr S. G. Boatman was appointed as a Plant Physiologist on 2 November. At the end of the year one research appointment remained vacant.

Miss Devadoss was appointed as a typist and reported for duty on 1 May.

The following junior field assistants resigned to take up appointments elsewhere: Mr Ting Keong, Mr Yong Teck Wah and Che Mohd Noor bin Mohd Zain. Mr B. Manickam was appointed as a field assistant at the R.R.I. Experiment Station at Sungei Buloh.

The following field and laboratory assistants were appointed to fill the vacancies created by the above mentioned resignations: Mr C. Selvarajah, Mr T. Thalayasingam, Mr Soh Kim Chwi and Miss Barbara Tan Teik Chooi.

Mr. P. Ragoothaman was appointed as a temporary typist and when he was transferred to Pathological Division he was replaced by Miss Liew Kon Kew.

The newly appointed Mr Soh Kim Chwi resigned on 31 December to become a Cadet in the Federation Army.

Research Officers made 55 advisory visits to Estates, and 126 visits to Estates in connection with research work. Advisory visits concerned planting material, tapping systems and yield stimulation. Research visits were all concerned with the conduct of the Division's Experiments but included advisory work. Field Assistants made 164 visits to Estates in connection with experiments totalling 628 days. Inspectors visited 101 estates, spending 234 days, in connection with the identification of clones and approval of seed collection areas.

Three hundred and thirty visits were made to the Rubber Research Institute Experiment Station by Graduate Officers in connection with the work at the Station.

Dr P. R. Wycherley made a tour of five weeks to rubber estates in British North Borneo.

The following articles were prepared for the *Planters' Bulletin* and published during the year:

'Clonal Seed Collection'; 'Tapping Prior to Replanting'; 'Planting Density' (in co-operation with Statistician); 'Stimulant Treatment—a Caution'; 'Ridley Centenary at Singapore'; 'Is Mature Rubber Undertapped?'; Editorial—"Theory and Practice"; 'Correct Timing',

in addition to a number of notes and communications from letters.

'The Importation and Development of Strains of *Hevea brasiliensis*' by C. W. Brookson, was published in March 1956 in Volume 14 of the *Journal* of the Rubber Research Institute of Malaya.

Three further *Journal* Communications have been completed and submitted for publication:

'Poisoning Experiments with *Hevea brasiliensis*: I. Preliminary, Trials—Destruction of Trees with 2,4,-D and 2,4,5-T': II. 'Results of a Further Tree Poisoning with 2,4,5 T' and 'Stimulation of Bark Renewal of Hevea, and its Effect on Yield of Latex'.

Work continues on two more projected *Journal* publications.

Three lectures were given during the year under review:

Dr P. R. Wycherley on 'Hevea Planting Material' to the South Johore Branch of the Incorporated Society of Planters;

Mr P. de Jonge on 'Tapping and Yield Stimulation' to the North Selangor Branch of the Incorporated Society of Planters;

Mr P. de Jonge on 'Tapping and Yield Stimulation' to the Muar/Malacca Branch of the Incorporated Society of Planters.

RESEARCH

BREEDING, SELECTION AND TESTING

Hand pollinations

The results of the 1956 hand pollination programme are set out in Table I.

TABLE 1. FINAL RESULTS OF HAND POLLINATIONS 1956

	Family	No. of pollinations	No. of fruits harvested	% of suc- cess	No. of seeds planted	No. of seeds ger- minated	% of germi- nation
1	RRIM 501 x LCB 1320	491	29	5.9	86	77	89.5
2	PR 107 x RRIM 501	1138	80	7.0	241	201	83.4
3	PR 107 x RRIM 623	1117	69	6.2	207	116	56.0
4	PB 5/60 x RRIM 501	1233	106	8.6	319	240	75.2
5	PB 5/60 x RRIM 603	848	35	4.1	105	79	75.2
6	PB 49 x PR 107	1150	125	10.9	374	320	85.6
7	PB 49 x RRIM 603	443	20	4.5	60	52	86.7
Total		6420	464	7.2	1392	1085	77.9

Though 520 fruits were growing to maturity 54 fruits were lost due to squirrels damaging the fruits and wind damage.

Five hundred and twenty fruits had set and were growing well, resulting in an initial success of 8.1%. This again justifies the use of a small number of well trained pollinators. Squirrels damaged 54 fruits, so that the final success was 7.2%.

Seedling Families

Tapping has commenced of the 1948 hand pollinated seedlings, which were planted in one tree plots in four blocks at the R.R.I. Experiment Station in October 1950. The trial contains 459 seedlings of 19 families.

Three hundred and ten stumps of seedling trees obtained from the 1954 hand pollination programme were planted out in single tree plots in 3 replications per family. One hundred specially treated seedlings were also included in this experiment. Nine hundred basket plants of the 1956 hand pollination programme were planted in single tree plots in 5 replications per family with Tjir 1 selfed stumps as control.

Clones

A small scale clone trial of the 1954 hand pollination programme seedlings was budded in a simple lattice design of 512 plots, each plot containing seven planting points. Clone RRIM 501 is the control.

A trial containing 100 clones obtained through exchange between Far Eastern Research Institutes and the most promising Malayan clones has been budded at the R.R.I. Experiment Station during the year under review.

The large scale trial of clones RRIM 619 - 630 was brought into tapping at the R.R.I. Experiment Station. The first year of tapping of the large scale trial of clones RRIM 600 - 618 was completed and the yield and growth data statistically analysed for publication.

No flowering was observed on the branch and crown buddings of clones FX 1619, FX 25 and FX 3363 and the hand pollination programme with these *Dothidella* resistant clones had to be postponed again.

Mr L. W. Beery Jnr visited the Institute and the currently available *Dothidella* resistant clones were considered. The best breeding clones are said to be FX 25, FX 516, FX 652 and FX 4037. In addition FX 516, FX 652 and FX 2754 are all good top clones. A recommendation was also made that South East Asia should acquire FX 3810, FX 637, FX 3925, FX 2261, FX 3844, FX 3846, FX 4071, FX 4072, FX 4073, FX 1042, FX 3703, FX 349, FX 3910, IAN 45-717, IAN 45-710, IAN 45-713 and IAN 45-873.

In connection with this matter the acquisition of certain clones from the Rubber Research Institute of Malaya, the Algemeen Proefstation der A.V.R.O.S. and the Proefstation der C.P.V. has been suggested to the U.S. Department of Agriculture, Plant Introduction Section, by Mr Beery.

The Rubber Research Institute of Malaya is acting as the Eastern quarantine station, in conjunction with the facilities for disinfection already established in cooperation with the Commonwealth Mycological Institute at Kew, for an exchange between the Indonesian and American territories. The Proefstation der C.P.V. has made available to the United States Department of Agriculture clones PR 226, 228 and 231, which had already been introduced into Malaya with AVROS 385 from the Proefstation der A.V.R.O.S., which has forwarded during the year budwood of clones GX 20899, 20900, 20908 and 20909; clone FX 349, 614, 649, 3810, IAN-45-717 and 45-873 were received from America, and now all the above have been established in this Institute's nurseries.

Seeds of *Hevea brasiliensis* were sent to England and through the help of the British Rubber Producers' Research Association were irradiated with high energy at the Atomic Research Station at Harwell. Seeds receiving 4,000 rads or higher dosages produced seriously distorted seedlings, 2,000 rads retarded germination. Unfortunately the

despatch and return of the material was disrupted by air transport difficulties during the Middle East crisis; the assistance of the Curator and his staff of the Royal Botanic Gardens, Kew, in caring for the seedlings during this unexpected interruption is gratefully acknowledged. However, losses due to delays and transportation at an unsuitable stage have made the results difficult to interpret.

Nine 600 series clones have been chosen from the first selection (RRIM 600 – 618) as being the most promising at the moment. The choice was made on the basis of performance in small scale trials at the Experiment Station; of observation on immature trials on cooperating estates and of yields for the first nine months of tapping in the large scale trial at the Experiment Station. A list of the nine clones and notes on them have been distributed to enquirers. It was made quite clear that the object of this list is to help planters to choose the most promising clones for immediate multiplication and to warn them that the ultimate selection may be quite different. The list will be revised as necessary at the end of this year and yearly thereafter.

In addition to his normal work for the Botanical Division, the senior field assistant has visited six Soils Division manurial experiments to obtain data on the effect of different manurial treatments on bark.

TRIALS OF SELECTED PLANTING MATERIAL ON ESTATES

Projected Trials

The Research Officer in charge of RRIM variety trials visited the sites of two exchange clones trials which were to be budded in 1956. These sites had later to be abandoned due to shortage of budwood.

The proposed site of an exchange clones trial to be budded in 1957 was visited later in the year. The exchange clones trial at the R.R.I. Experiment Station was budded in November/December 1956.

Mature Trials

Nine estates having pre-war variety trials were visited by the Research Officer in charge and fourteen by field assistants who made routine observations. One pre-war 500 series clones trial was abandoned, as the area is scheduled for tin mining.

Both post-war 500 series clones trials were visited, one was opened for tapping in October 1956 and the other is expected to come into tapping in the first half of 1957.

A review of the performance of clone RRIM 519 both at the Experiment Station and in Estate trials was made during the year and it was decided to include the clone in the 1957-58 Planting Recommendations as suitable for budding on a moderate scale. RRIM 519 was not originally recommended because of the relatively high incidence of brown bast in the trial at the Experiment Station. However, brown bast incidence has not been unduly high in estate trials. In one estate trial RRIM 519 has yielded more than RRIM 501 over a period of eight years of tapping.

Clone RRIM 526 remains in the Planting Recommendations as suitable for moderate scale planting because only one of the pre-war trials in which it was budded is still being recorded. RRIM 526 is present in both of the post-war 500 series trials, from which yield records will soon be available.

Immature Trials

All 21 estates participating in the RRIM 600 series distributed block trial were visited by the Research Officer in charge and 16 were visited by field assistants to make routine observations and to mark trees for thinning. Blocks on two of the estates were opened for tapping in December.

Girth measurements taken from the distributed blocks at two and four years from cutting back were analysed and no significant differences could be established between clones.

RRIM 600 series complete trials on 29 estates were visited by the research officer in charge and 31 by field assistants. Two 600 series clones trials were budded in November and one trial had to be abandoned.

PROPAGATION AND PLANTING TECHNIQUE

Planting Technique

The panel and top-budding experiment at the Rubber Research Institute Experiment Station was finally thinned. The planting distance and planting density trial was also thinned to maintain the same relative densities, and to dispose of runts and some supplies.

The results of a pre-war density of planting experiment carried out on clone AVROS 50 have been prepared for publication. A short article on this experiment was published in the January 1956 issue of *Planters' Bulletin*.

Tree Poisoning

A tree poisoning experiment was concluded in the first half of 1956 and has shown that a 5% concentration of the normal butyl ester of 2,4,5-T dissolved in high grade diesel oil is not a completely satisfactory tree killer. Tapping was continued, after application of the poison, on a half circumference cut tapped alternate daily. Increased yields were obtained for a period of four to five weeks on downward tapping and nine to ten weeks on upward tapping. The extra yield more than covered the costs of poisoning.

A detailed report on this experiment has been submitted for publication.

Vegetative Propagation of Hevea brasiliensis

Promising results have been obtained in experiments on rooting of leaves and leaflets of *Hevea brasiliensis*. It has proved possible to establish a root system on these leaves. Photographs of such rooted leaves are shown below.



Figure 1. Rooted leaflet of three year old seedling.



Figure 2. Rooted petiole of leaf of three year old seedling.

For rooting the leaves require light shade and a saturated atmosphere. A special mist propagator has been built for this purpose. Washed, coarse river sand was used as a rooting medium. Further investigations are in progress.

Stock Scion Relationship

All pre-war stock scion experiments at the R.R.I. Experiment Station have been discontinued and the results are being analysed. Comments are reserved until all experiments have been analysed.

TAPPING

Full spiral tapping experiments continued, but it is intended to discontinue most of these in 1957. The results to date show that:

- 1 girth increment of young and old budded trees is retarded by S/1.d/4.100% tapping
- 2 proportion of rubber in lower grades is increased by tapping a full spiral cut
- 3 the yield of trees tapped on the S/1.d/4.100% system is of the same level as that of trees tapped on S/2.d/2.100% system. There are some marked clonal responses to full spiral tapping, already mentioned in the 1955 *Annual Report*
- 4 full spiral tapping at an intensity less than 100%, produced by introduction of resting periods or lengthening the interval between successive tappings, results in significantly less crop and only those clones which reacted unfavourably to S/1.d/4.100% tapping seem to benefit from the reduced intensity by gradually improving their (low) yield level
- 5 the most promising full spiral tapping system appears to be the system in which tapping is done third daily for a period of a year followed by four months rest, (S/1.d/3.12m/16.100%), which gave a similar yield to S/1.d/4.100% and S/2.d/2.100%, but caused no retarding effect on the growth in an experiment on young Tjir 1 buddings over a period of 6 years continuous tapping.

The economy of this third daily periodic full spiral tapping system was almost the same as that of S/1.d/4.100% tapping and, under the conditions of the experiment, the brown bast incidence did not differ between these two systems. An advantage with regard to bark consumption was recorded for the third daily relative to the fourth daily 100% intensity systems.

A new experiment will be set up on young vigorously growing buddings to test the above S/1.d/3 periodic 100% system.

Tapping Experiments on Planting Material Sensitive to Brown Bast

One experiment is being carried out on clone G1 1 and indicates that half spiral third daily tapping (S/2.d/3.67%) is superior to 100% intensity periodic changeover systems (S/2.d/2.2x6m/12.100% and S/2.d/2.2x12m/24.100%) in keeping the brown bast incidence low. The two 100% changeover systems resulted after three years of tapping in brown bast incidence of respectively 13.6% and 10.1%, whereas S/2.d/3.67% tapping induced a brown bast incidence of only 2.1%.

The mean yearly yield on third daily relative to alternate daily tapping in the three successive years was 78.3%, 82.2% and 89.9%. A further increase may be expected in coming years, due to the increasing number of brown bast affected trees in the alternate daily tapped tasks.

A second experiment was commenced in May 1956 in which S/2.d/2.100%, S/2.d/2.2x12m/24.100% and S/2.d/3.67% are being compared on young P.B.I.G. seedlings and in which the treatment S/2.d/2.100% has been confounded with the application of yield stimulating formulations containing 0.5% and 1%, 2,4,5-T.

This experiment has already yielded conclusive information with regard to stimulation of such young trees. Both stimulants induced an increased yield but also a statistically significant retarding effect on the growth of the seedlings within six months after application of the stimulant. As this experiment is carried out on a cooperating estate no further application of a yield stimulant was given. The experiment is now continued as an ordinary tapping experiment comparing 100% and 67% intensity systems.

A similar tapping cum yield stimulation experiment has been laid out on PB 86 buddings which will be opened for tapping after the 1957 wintering season. Two levels of manuring have also been confounded with the tapping treatments.

High or Ladder Tapping

Budded trees generally respond with an increased yield when tapped on a high cut in virgin bark, as compared to tapping of a low cut in bark of second renewal. Very marked clonal differences have been established in an experiment carried out on budded trees of nine clones planted in 1930.

TABLE 2. YIELD EXPRESSED IN LB OF DRY RUBBER PER TREE PER YEAR

Clone	1 Tapped on high cut in virgin bark V/2.d/2.100%		2 Tapped on low cut in bark of 2nd renewal S/2.d/2.100%		3 Tapped on 2 cuts one on high and one on low 2C/2.d/2.200%	
	1st yr	2nd yr	1st yr	2nd yr	1st yr	2nd yr
AVROS 152	10.7	10.3	10.0	11.9	17.6	18.3
AVROS 49	13.2	13.2	11.1	12.5	19.3	19.4
PB 23	10.0	11.7	8.1	10.6	20.2	20.2
PB 186	24.1	20.2	10.4	13.1	26.3	25.4
BD 5	10.9	10.3	9.9	11.1	18.5	19.2
Tjir 1	17.2	12.3	12.2	14.5	30.5	28.9
Pil A44	18.9	12.8	11.3	12.1	22.5	20.2
Pil B84	22.7	15.9	11.2	14.0	33.2	27.1
AVROS 50	8.8	9.3	8.6	10.9	20.0	23.1
Mean	15.2	12.9	10.3	12.3	23.1	22.4

Only clone PB 186 yields significantly better on the high cut as compared with tapping of the low cut in the second year of ladder tapping. The experiment has now been confounded with application of a yield stimulant to the high cuts.

The maintained high yield level of the buddings tapped at 200% intensity is striking.

Seedling trees—Ladder tapping of old unselected seedling trees results in a slight decrease in yield per tree per tapping, but all trees can be tapped in thick virgin bark whereas normally many trees have to be left out because the renewed bark is too thin. Application of a yield stimulant to ladder tapped cuts has given very satisfactory increases in yield as opposed to application of a yield stimulant to low cuts in poorly renewed bark, which was hardly economical, as shown in Table 3.

Intensive Tapping

The tapping system 2C/2.d/2.200% has produced outstanding results on both budded and seedling material. One high V/2 cut is tapped in the virgin bark and one low C/2 cut in the renewed bark, care being taken that the cuts remain at least four feet apart and preferably on opposite sides of the tree. The reaction of 9 clones to this system is given in column 3 of Table 2 but it should be noted that the figures in column 3 are not strictly comparable with those of columns 1 and 2 as they are based on a different number of trees.

On seedling trees of 25 — 26 years of age the yield was nearly doubled during the first year of 200% tapping and very marked increases in yield were obtained after application of a yield stimulant in conjunction with this system as shown in Table 3.

TABLE 3. MEAN YIELD EXPRESSED IN GRAMS OF DRY RUBBER/TREE/TAPPING DURING THE FIRST YEAR OF TAPPING

Tapping systems	Yield	
	in grams	as % of control
1 S/2.d/2.100% — control (in bark of 2nd renewal)	20.1	100%
2 as 1 + stimulant below cut at 6 months intervals	22.9	114%
3 V/2.d/2.100% — high cut tapping	19.0	95%
4 as 3 + stimulant below cut at 6 months intervals	31.2	155%
5 2C/2.d/2.200%	36.4	181%
6 as 5 + stimulant to high cut at 6 months intervals	45.7	228%
7 as 5 + stimulant to both cuts at 6 months intervals	52.7	262%
8 as 5 + stimulant below alternating high and low cut at 3 months intervals	51.2	255%

Interaction Between Tapping, Stimulation and Manuring

An experiment has been designed for layout on a cooperating estate using clone PB 86 in which S/2.d/3.67%; and S/2.d/2.100% with stimulant application are compared at two levels of manuring. This experiment is being carried out in cooperation with the Soils Division.

A second experiment is being carried out in cooperation with the research unit of a leading rubber company in which S/2.d/2.100%, S/2.d/3.67% and 2S/2.d/3.133% are compared at four levels of manuring on budded trees of clone PB 86.

Tapping and Latex Properties

In previous years it has been shown that the properties of latex concentrate and dry rubber were not affected by the long term use of yield stimulants. The Chemical Division cooperated with tests in the high and 200% intensity tapping experiments the results of which are not yet available.

PHYSIOLOGY AND MORPHOLOGY

Yield Stimulation

Two long term experiments continue, one on clonal seedlings and one on budded trees of nine clones, both tapped on bark of second renewal. Satisfactory increases in

yield are still being obtained after continued half yearly treatment of the seedling trees with yield stimulants from February 1952.

The budded trees have been treated also every half year from May 1953 onwards and have likewise reacted favourably. The overall increase to date is 25% for the clonal seedlings and 33% for the buddings. Of the buddings only clone AVROS 50 showed a disappointing response to the yield stimulant.

The downward trend of response to successive half yearly application of a yield stimulant, which was noted on the clonal seedlings, was completely reversed when a new panel was opened in bark of second renewal on the opposite side of the tree. No increased brown bast incidence has been observed and no effect on growth could be detected on these fully mature trees. The thickness of the renewed bark was significantly increased during the first year of renewal, which advantage was lost in subsequent years. The properties of latex concentrate and dry rubber from the trees were normal.

Six new yield stimulation experiments were set up in November 1955 at the R.R.I. Experiment Station. The first experiment is on clonal seedlings tapped on bark of second renewal and a comparison is being made between several yield stimulating mixtures applied at different intervals either below or above the tapping cut. The detailed results of this experiment will be published elsewhere, but two conclusions stand out (1) the stimulant mixture containing 1% 2,4,5-T has proved its superiority over other commercial yield stimulants and (2) application at three months intervals of a yield stimulant to scraped bark below the tapping cut has given the highest yield increase. Coming years will show if this lead can be maintained.

The second experiment is mainly an intensive tapping experiment and has been mentioned on page 34 in this report.

The third experiment compares upward and downward tapping in virgin bark of old unselected seedling trees. During the first year of tapping the upward tapped trees yielded more latex than the downward tapped trees. The reaction of upward tapped cuts to application of a yield stimulant is superior to that of downward tapped cuts probably due to the uninterrupted area of bark from which the latex is obtained when tapping upwards.

The fourth experiment was meant to find the optimum concentration of 2,4,5-T in the standard carrier of 5 parts of palm oil and 3 parts of petrolatum. The highest increased yield was obtained with a 1½% acid equivalent concentration of 2,4,5-T. The 2% concentration yielded significantly less at a level similar to that obtained with the 0.5% concentration of 2,4,5-T. The standard 1% 2,4,5-T containing mixture yielded slightly less than the 1½% concentration. This experiment has been discontinued.

The fifth experiment was an effort to find a carrier which would penetrate into the bark without prior scraping. All treatments yielded clearly less than the standard 2,4,5-T mixture applied to scraped bark. The experiment has been discontinued.

A promising commercial preparation was tested in an experiment which was not statistically designed, and induced, without scraping, a yield increase similar to that obtained with the standard 1% 2,4,5-T mixture when applied to scraped thick virgin bark.

Two large scale experiments have been set up on budded trees, in which tapping of bark of first renewal has just begun; a wide range of tapping systems will be tried confounded with the application of a yield stimulant. No results are yet available.

One experiment was set up on young buddings of clones PR 107 and AVROS 352 to compare the efficiency of the following substances in a range of concentrations as yield stimulants:

- 2,4-dichlorophenoxy acetic acid
- 2,4,5-trichlorophenoxy acetic acid
- 2,4,6-trichlorophenoxy acetic acid
- 2,4-dichloro, 5 fluoro-phenoxy acetic acid
- diphenyl urea
- coconut milk (concentrated by freeze drying)

No results were available at the end of the year under review.

Translocation of Growth Substances

Various bioassay methods are being considered for quantitative determination of auxins in the bark of the rubber tree. When a satisfactory method has been developed this may be used in connection with projected studies on the translocation of 2,4,5-T.

Anatomy

A large scale stimulation of bark renewal experiment was completed in early 1956 and microscopical investigation of the renewed bark has been made. It was found that all known formulations for stimulation of bark renewal give a thicker bark during the first year of renewal, which effect however is lost in subsequent years. Addition of growth substances to these formulations greatly increased the activity of the cork cambium but had no influence on the vascular cambium from which the latex vessels are laid down.

During the third year of renewal the control trees showed a better increase in bark thickness than the treated trees. This may be due to mechanical hindrance by the thick layer of strongly sclerenchymatous periderm tissue induced by the bark stimulants. A report on this experiment has been submitted for publication.

Samples of seedlings grown under various micro nutrient levels of copper have been sectioned for microscopical investigation; no anatomical differences could be detected in the living tissue. Leaves of plants receiving excess quantities of molybdenum have been investigated microscopically and no anatomical abnormalities could be found.

ECOLOGY

Cover Plants

New species—Three legumes were introduced from Kenya and established in a nursery. *Lotononis bainesii* was the most promising at first, but slowly died out later, probably due to fungal attack. *Teramnus repens* was a failure, but *Desmodium uncinatum* is still growing. A little seed has been saved of each species for further trial.

The new species of *Clitoria* previously reported, grows well at the Institute and at the Experiment Station, but it is too early to predict anything about its performance in comparison with other legumes.

Field experiments—Two field trials to compare the effects of different types of ground cover on the growth of hevea have been started, both are situated in replanted areas of the R.R.I. Experiment Station. In one trial, grasses, *Mikania*, creeping legumes, *Flemingia congesta* and natural shrubs are compared. In addition the effect of applications of phosphate to the non-leguminous covers is studied. The other trial is similar, but a wider range of species are compared and phosphate is applied uniformly.

Seed production—A preliminary investigation has been made of seed production by *Pueraria phaseoloides*. A number of insect pests which feed on the young flower buds and seeds were found, and reasonable control was obtained by spraying with insecticides. However, even when the pests were eliminated and young pods containing fertilised ovules were obtained, these pods often fell off before completing their development, so that no seed was finally obtained. The development after fertilisation to mature seed seems to be influenced by climatic factors.

Seed Testing—During the year 77 samples of leguminous seeds were received from commercial suppliers and estates for purity and germination tests. Twelve of these were special samples taken in triplicate from different parts of the same shipment, and twice samples from the same origin were sent by air in addition to the samples from the bulk which travelled by sea. We thank Messrs Hooglandt & Co. Ltd, Singapore, for their help.

Samples taken from the top, middle or bottom of the bags were not consistently better or worse than the others, judged either by total viability or germination without pretreatment.

In most cases the results for the three samples from the same bulk agreed reasonably well, but occasionally wide variations were found. This illustrates that the selection of the sample has a great influence on the final result, thus too great reliance cannot be placed on the individual results of testing small samples from large bulks. However, the studies of these commercial samples are yielding useful information on the quality of seed available and its response to pretreatment.

Comparisons of various methods of testing and pretreatment have been made, including the influence of the periods of acid treatment and washing.

Seed storage—An experiment on the storage of seed of *Pueraria phaseoloides* has been established. The most interesting result so far is that when stored under damp conditions the total viability shows little change, but the number of seed which germinate without pretreatment is reduced, i.e. the proportion of 'hard' seed increases.

Distribution of material—Cuttings of *Stylosanthes gracilis* and seed of *Flemingia congesta* were distributed to estates.

Herbarium—Sheets of 264 species have been added to the herbarium. An index of the herbarium has been prepared, and another index to all species mentioned in correspondence on natural and introduced plants growing in rubber planted areas.

Ninety-six plant specimens were received for identification and comment.

ADVISORY

Tours and visits—Fifty-five purely advisory visits were made to estates on request. On the other one hundred and twenty-six visits made, advisory requests were also met in addition to the experimental object of the visit. All visits made by Inspectors and mentioned on page 27 of this report can be classified as advisory.

Dr P. R. Wycherley made an advisory tour of five weeks to rubber estates and holdings in British North Borneo. There has been a heavy demand for the report on that visit.

A further increase in the amount of correspondence received and despatched was noted:

	Letters received	Letters despatched
Advisory	2436	2184
Correspondence with Manager Expt Stn	64	277
Internal correspondence	295	686
Experimental planting	633	605
	3428	3752

The increase in correspondence is solely on the advisory side as can be seen tabulated below:

Seed gardens	11
Identification of clones	305
Choice of clones	407
Choice of planting material	41
Exchange of planting material	593
Identification of rubber seeds	125
Hedge planting and densities	71
Tree poisoning	52
Tapping	110
Yield stimulation	117
Identification of cover plants	122
Testing of leguminous seed	77
General planting enquiries	405
	2436

Ninetyseven visitors also called upon the Division.

The analysis of advisory correspondence follows.

Breeding and Selection

Eleven enquiries were received regarding seed gardens and their establishment, and 305 largely with regard to identification of trees in prospective seed collection areas; a few only of the queries being requests for nursery identification of budwood.

The inspection of prospective seed collection areas has been a major task during 1956 and at the end of the year some 20,000 acres had been inspected for collection of clonal seed, mainly Tjir 1 selfed but also Tjir 1 crossed with other clones.

A revised list of approved seed collection areas was submitted to the Chairman of the Boards of the Government Rubber Replanting Schemes for publication.

Four hundred and seven letters were received concerning the choice of clones for planting and fortyone concerning the choice of seedling families. Five hundred and ninetythree letters dealt with the exchange, despatch and receipt of planting material. One hundred and twentyfive letters dealt with the identification of rubber seeds.

Propagation and Planting Technique

Seventyone queries were received under this heading concerning hedge planting and planting distances and densities and 52 concerning tree poisoning.

Tapping

One hundred and ten queries were received on subjects under this heading mainly on intensive tapping prior to replanting.

Physiology

One hundred and seventeen letters were received, mainly on the subject of yield stimulation.

Ecology

One hundred and twentytwo letters were received concerning the identification of cover plants, and 96 identifications were made. Seventyseven samples of leguminous seed were received and tested.

Nucleus supplies of seed of *Flemingia congesta* were also distributed.

General Planting Enquiries

Four hundred and five queries on general subjects were received.

Budwood of RRIM clones sold from the R.R.I. Experiment Station to estates for multiplication and use in new plantings and replantings amounted to 1535 yards of the RRIM 500 series clones and 6542 of the RRIM 600 series clones. One thousand six hundred and thirtyfive yards of other clones was also sold making a total of 9712 yards.

Two thousand and forty yards of budwood of clone Tjir 1 were despatched in regular consignments to Sarawak and 477 yards of budwood of several clones were sent to Indochina, Nigeria, India and New Guinea.

C. W. BROOKSON
Head of Botanical Division

Pathological Division

The Head of Division Dr A. Newsam, Pathologist Mr R. N. Hilton, Microbiologist Mr R. A. Fox and Assistant Pathologist Mr K. P. John were on duty throughout the year. The Field Research Officer Mr F. W. Hutchison was on long leave from 30 April onwards. The Assistant Entomologist Mr B. S. Rao returned to duty on 27 August 1956 having obtained the Diploma in Plant Pathology and Protection of the University of Bristol.

Three papers reporting the work on coal tar fungicides, carried out at Long Ashton Research Station on behalf of the RRIM, have been reprinted in the *Journal* as Communication 299, prefaced by a paper by Mr F. W. Hutchison on the testing of coal tar fungicides for the control of mouldy rot. The work at Long Ashton sponsored by the RRIM was carried out by Mr G. V. Coles under the direction of Dr J. T. Martin, with the collaboration of Dr R. J. W. Byrde.

Advisory articles in *Planters' Bulletin* dealt with *Gloeosporium* leaf disease, mouldy rot (revising an article that appeared in 1953), cockchafers and secondary leaf fall. In addition, brief notes were contributed on termite control, *Rhizobium* compost cultures (when the changeover was made from distributing tube cultures) and an unusual effect of lightning.

Dr A. Newsam lectured on the recognition of pests, to planting associations in Central Johore and Central Perak.

RESEARCH

DISEASES OF THE ROOT SYSTEM

Field experiments—Experiment G-50 in which different methods of stump poisoning are being compared, has had its sixth and seventh rounds of inspection and treatment. The level of incidence has become low enough that what follows cannot materially affect the overall result. It is therefore decided that the next round of inspection and treatment will be the last, after which the data will be analysed in detail. The indications are that the methods of stump poisoning applied (for which see the 1950 *Annual Report*) do not differ much in their effectiveness; that stump poisoning generally reduced the incidence of disease in the young stand by 60% as compared with leaving the stumps unpoisoned; that treating the cut surface of the stumps with Solignum had an intermediate effect, as was expected on the supposition that spore colonisation of the cut surface is one mechanism by which the stumps of felled trees become infected with root disease.

In experiment CI-51, the layout of which is given in the *Annual Report* for 1951, the fifth and sixth rounds of inspection and treatment have been completed. To the preliminary statement of the results given in the report for last year should be added that the incidence of disease in the young stand, instead of continuing to fall from the fourth year onwards as treatment brings the disease under control, has taken an upward turn. It appears that covers are transmitting the disease from infected surface timber, but to explain fully the upward trend it will be necessary to continue making observations in the experimental area for at least a year longer.

With the loss of the markers of diseased trees in experiment WC-54, it remains only to accumulate records of root disease incidence and the cost of control in the two

otherwise comparable areas where diseased trees of the old stand were removed from one, isolated in the other.

A new experiment (CI-56) has been laid down on Carey Island, to compare normal butyl 2,4,5-T with sodium arsenite for poisoning trees and stumps. The poisoned trees have not been left standing but were felled, one month or two months later. The six treatments have been replicated four times on one-acre plots which have been further divided in two, half the stumps receiving in addition a surface treatment with creosote. Some of the stumps were opened up six months after poisoning, to make a preliminary comparison between the poisons on the basis of the death of the roots. There was little to choose between them.

To supplement the above experiment, observations are being made in two sites (West Country Estate and the R.R.I. Experiment Station, Sungei Buloh) on the rate of death of roots of trees felled at progressive intervals after poisoning. At Sungei Buloh, too, the surface treatment of stumps with creosote is being repeated; while, in another area, tree poisoning procedures are being investigated.

Trees that have been thinned out on the Experiment Station have been used to study the effects of various poisons on stumps already inoculated with root disease, and to observe the effect of inoculating poisoned stumps. In general our views on the effect of poisoning are borne out — a parasite that has already penetrated a stump is not killed by the poison but, once roots killed by the poison are invaded by decay organisms, the root disease fungi will not readily penetrate them.

More than forty species of jungle trees have been inoculated with infected rubber roots. On many there has been superficial growth of the fungi, with some penetration of the bark, but no extensive infection has resulted. This is true even of a rubber tree growing in the jungle. It appears that conditions in this area are in some way unfavourable for root disease development.

An experiment is in hand to find whether internal spread of *Fomes lignosus* is possible in infected roots when the fungus is prevented from growing superficially. So far it appears that preventing external growth halts the infection. As a complement to this experiment, various materials have been added to soil in the hope of making it fungicidal for a prolonged period, bearing in mind that soil treated with the insecticide aldrin can be made toxic to termites for several years.

Fundamental studies—Fundamental studies of the root disease fungi have been continued, but of necessity at a reduced rate during the absence of the Field Research Officer, when the Microbiologist had the additional work of supervising field experiments. Effort has mostly been directed towards learning more about the factors that determine the spread of root diseases—the effect of soil factors on growth; rhizomorph initiation; associated soil organisms—and interesting observations have been made bearing on saprophytic spread. To facilitate the study of decaying timber a collection of wood rotting fungi is being built up.

A major undertaking has been the installation of a group of constant temperature rooms. This is recorded here because, although constant temperatures are needed for almost all quantitative work with biological material, it is in connection with work on the root disease fungi that the need has been most acutely felt. The installation has been completed and is working correctly, giving temperature control in the range 60°F – 90°F with an accuracy of $\pm 2^\circ\text{F}$.

DISEASES OF THE TAPPING PANEL

Testing a new mouldy rot fungicide—Field tests with a proprietary tar acid fungicide submitted last year for official approval for the control of mouldy rot have been completed. In last year's test the highest concentration applied was still less effective than the accepted standard. Further phytotoxicity tests showed a concentration of 30% to be the maximum that is safe from bark burning. At this strength the disease was brought under control in this year's trials after nine applications. It will therefore be a satisfactory material for treating mouldy rot provided that the high concentration at which it must be used does not render it uneconomic.

Laboratory and field tests of standard form have been carried out with five tar fractions submitted by a producer of tar acid fungicides, following on the work reported in *Journal Communication* 299. Their performance was, however, disappointing, phytotoxicity limiting the concentrations at which they could be used to levels at which they compared unfavourably with the best approved materials.

Certain non-aqueous materials, including one that is approved for treating mouldy rot, have been given a field test. They were applied on a non-tapping day, with three alternate-daily tappings between applications. The most recently tapped bark, below the treated band, became mouldy to varying degrees after three or four days.

SECONDARY LEAF FALL

The distribution of thirtyfour reports of secondary leaf fall received during March, April and May are shown in the first Table; the results of examining 132 specimens are given in the second Table, drawn up as in previous *Annual Reports*. There were three further records during refoilation after the second wintering season, in the third quarter of the year. Secondary leaf fall was not severe. As is usual, the first reports received mostly involved *Oidium*; later, *Gloeosporium* became the dominant parasite.

DISTRIBUTION OF REPORTS OF SECONDARY LEAF FALL

Territory	March	April	May	Total
Kedah	9	1	—	10
Perak	3	6	—	9
Negri Sembilan	4	4	—	8
Selangor	1	4	2	7
Totals	17	15	2	34

INCIDENCE OF THE PARASITES ASSOCIATED WITH CASES
OF SECONDARY LEAF FALL

Parasite	Percentage of cases in which:			Mean intensity of attack
	March	April/May	no other parasite present	
<i>Oidium</i>	67	33	9	2.3
<i>Gloeosporium</i>	53	47	11	2.4
Mites	65	35	1	1.9
Thrips	61	39	0	1.4

OTHER LEAF DISEASES

Control of bird's eye spot—A small scale assessment trial of a number of fungicides with wetting agents or a sticker added was carried out on the Experiment Station. Plants were treated singly, enclosed in a spray tower. Analysis of the results showed certain treatments (in particular mercurised copper oxychloride) to result in treated plants being significantly heavier than untreated controls. When selected treatments were used on a plot scale, however, the results were disappointing—as attempts to control this leaf disease have so often been in the past.

Effect of nutrition on bird's eye spot—In an experiment carried out jointly with the Soils Division, plants grown in sand culture in the open were given three levels of nitrogen combined with two levels of calcium. Results were assessed as lesions per leaflet. Statistical analysis showed a significant effect of nitrogen, increasing nitrogen increasing the amount of disease. No effect of calcium was demonstrated.

DEFENCE AGAINST SOUTH AMERICAN LEAF BLIGHT

Aerial spraying trials—Results of the experimental aerial applications of normal butyl 2,4,5-T to mature rubber trees as a defoliant have been analysed and a report on the investigation is being prepared for the *Journal* by Mr F. W. Hutchison.

STEM AND BRANCH DISEASES

Pink disease—A study of pink disease, initiated last year, continues. The course taken by the disease is being studied by maintaining a watch on naturally infected trees and 100 artificially infected on the Experiment Station. Dry weather halts the infection; many lesions fail to become active again when wet weather returns. Spore inoculations have not led to an infection, yet it is supposed that spores play a part in disseminating the disease. An automatic spore trap operated close to an infected branch has shown that basidiospores can be liberated in vast numbers over brief periods that are presumed to be determined by climatic factors, though the nature of these has not been established.

Clonal susceptibility to pink disease has also been investigated on the Experiment Station, which is uniquely suited to this purpose. In addition to RRIM 501, which has long been known to be exceptionally susceptible to infection, certain other clones are found to be affected above the average amount. Tjir 1 is one; more severely affected is RRIM 618, of which RRIM 501 is a parent.

A country wide survey of pink disease occurring on clone RRIM 501 was successfully carried out by postal enquiries and returns. Both estates and smallholdings were included in the survey. It brought out clearly what had previously been suspected—that 'Pink' is essentially a disease of inland areas. Apparent exceptions, which may help to explain the relationship, are being investigated.

TERMITES

Control measures—Periodical observations have been made on the toxicity to termites of soils of various types that had been treated with aldrin and dieldrin. In two soils the effectiveness of the former has been lost, though the latter remains toxic. In three other treated soils both insecticides are still toxic after two years. While there was no evidence of any difference in their persistence in soil, aldrin was recommended as the preferred material for estate use because it is cheaper. It remains to be seen whether it will be worth using the more expensive dieldrin. Laboratory tests have shown that the rapid inactivation of aldrin in peat (which

affects dieldrin similarly) can be overcome by increasing the rate of application. The results obtained with aldrin in the field have been so satisfactory that it is being applied protectively in all immature fields on the Experiment Station. Hitherto only attacked trees have been treated.

NEMATODES

Cover plants attacked by eelworms—Further inoculation tests with covers growing in pots in a glasshouse have shown that the common legume covers are attacked by different species or strains of root knot nematode.

ROOT NODULE BACTERIA

Preparation of a *Rhizobium* compost—The plan to replace tubes of agar slope cultures by packets of compost culture, for distributing *Rhizobium* to plantations, has been successfully completed. A great deal of preparatory work was done—modifying the compost to find the most suitable mixture for multiplication and survival of the bacteria; checking on the effects of fertiliser admixture and seed pretreatment, and finding a satisfactory method of packing the compost. The compost chosen is composed of equal weights of finely sifted soil and sifted coir dust, with 5% of calcium carbonate added. Before sterilising the moisture content is raised by adding rather more than equal parts by weight of water. Four days after inoculation it is tested to show that the culture is not contaminated; it is then sealed in prepared alkathene packets, roughly 10 grams to each. One packet is treated as equivalent to one tube of the culture as previously distributed, though it contains many times the number of bacteria.

Routine tests have shown the continuing effectiveness of the *Rhizobium* strain that is supplied for inoculation of *Centrosema pubescens*, *Calopogonium mucunoides* and *Pueraria phaseoloides*. New isolations of *Rhizobium* of proved effectiveness have been made from *Flemingia congesta*, *Crotalaria anagyroides* and *Tephrosia vogelii*.

ADVISORY

Root Diseases

Apart from requests for identifications, most correspondence and visits have as usual been concerned with methods of clearing old rubber and with control measures in immature rubber. It is still necessary to stress that root disease control is most economically carried out during clearing for replanting and the first five or so years of the life of a replanting. Too often treatment is left too late, with the result that the disease becomes established in the young stand and is more costly to eradicate the longer it is left. The economics of controlling root disease in mature rubber is another subject to which some attention has been paid, but it is complicated by many imponderable factors.

When high incidence of root disease is reported in a replanting it is often found that poisoning the stumps with sodium arsenite, as has long been recommended, had not been carried out. Smallholders, who have difficulty in obtaining sodium arsenite, have commonly left the stumps of felled trees unpoisoned in the ground. To what extent this will lead to excessive root disease interfering with the establishment of their replantings remains to be seen, but it is a risk that should be avoided. Normal butyl 2,4,5-T has now been advised as a stump poison on the strength of its observed effect on the rate of death of roots. A field experiment that will provide better evidence of

its value in reducing root disease incidence has been laid down. Meanwhile, the Rubber Industry (Replanting) Board has been advised to survey the root disease situation in smallholders' replantings, taking 1953 as the reference year. Advice has been given on the nature of the questions that might usefully be answered, and responsibility for analysing the data has been accepted. Returns from Replanting Subordinates of the R. I. (R.) B. were still coming in at the end of the year; analysis of the returns has yet to be started.

Leaf Diseases

The commonest leaf diseases are bird's eye spot, which is best treated by manuring to encourage recovery, and *Gloeosporium* leaf spot, against which fungicidal applications are sometimes advisable. Other leaf diseases that attract attention occasionally are anthracnose, *Colletotrichum* leaf spot, powdery mildew and algal spot.

Stem Diseases

Against pink disease, the most injurious stem infection, pruning is no longer advised. It is not only slow, but also its value in combatting the spread of the disease has been doubted. Further, many pruned branches bear lesions that have ceased to be active; though cutting them off removes unsightly deformities it also gives the tree a further set-back. The important thing is to treat active cases of infection promptly during wet seasons. To get round fast enough the operator needs to be able to treat affected branches from the ground; for this purpose he requires a sprayer equipped with a lance, and a nozzle that delivers a jet.

Non-Parasitic Injuries

Injury due to accidental poisoning by weed-killers is still frequently encountered, sodium arsenite being the commonest cause because it is so widely employed. Various leaf and stem malformations, bark-bursts and burrs, attract attention but are of no consequence. Lightning damage is another non parasitic injury commonly met with but often unrecognised.

Pests

With the advent of aldrin and dieldrin, termites have ceased to be a problem. Cockchafer grubs, which destroy the roots of young plants, have become more prominent during the year, but they still cannot be described as serious pests. They have been reported in ten places, the species most involved being *Leucopholis rorida*, *Holotrichia bidentata* and *Psilopholis vestita*. They have been found difficult to destroy in the field by insecticidal treatment of the soil. Of the various insects that attack the leaves and stems of young plants, mealy bugs and scale insects are most conspicuous. They are controlled, when necessary, by oil emulsion sprays. More damage is done by the larger (mammal) pests in young plantations near jungle.

A newly recorded pest is a lac insect (*Tachardia* sp.) found heavily infesting the underside of the branches of four-year-old buddings of RRIM 501 over an area of ten acres on an estate in Perak.

Towards the end of the year there were some locally severe outbreaks of pests of creeping legume covers — chiefly *Epilachna indica* on *Centrosema*, *Pagria signata* and *Chauliops bisontula* on *Pueraria* and *Calopogonium*. They have been found to be easily controlled by spraying.

Root Nodule Bacteria

Seven thousand nine hundred and sixty cultures of *Rhizobium* were supplied for inoculating cover crop seed, at first in tubes, from September onwards as packets of compost culture, of which more than four thousand five hundred were sent out.

General

Watercolour illustrations for a manual of diseases of rubber have been painted by Mr Hoh Choo Chuan whenever suitable fresh specimens were obtained. By the end of the year very few were lacking, and these have since been completed.

Summary of Advisory Work and Correspondence

Letters despatched	579
Specimens examined	344
Visits to estates and smallholdings	198
Interviews	101

ARTHUR NEWSAM
Head of Pathological Division

Chemical Division

At the commencement of 1956, the graduate staff of the Division comprised Mr W. G. Wren (Head of Division), Mr G. W. Drake, Dr W. A. Southorn, Mr H. M. Edmondson, Mr R. S. Gale, Mr J. E. Morris, Mr D. H. Taysum, Mr G. F. J. Moir, Mr B. C. Sekhar, Mr K. C. Sekar, Mr R. C. H. Hsia, Mr S. J. Tata and Mr S. T. Sethu.

Mr D. J. Graham continued to divide his duties between Experiment Station staff and Chemical Division staff.

Mr B. C. Sekhar returned from leave in January and was appointed as Research Officer. Mr Chong Yoon Hin, assistant biochemist, joined the staff in June. Dr Southorn proceeded on leave in April and Mr Morris in May. Mr R. C. H. Hsia proceeded to the U.K. on two years study leave in September.

Four Research Officer appointments remained vacant throughout the year, despite continual efforts to recruit new staff; these posts comprised Analyst, Chemical Engineer for development work, and two Rubber Technologists for work on T.C.R.

The Division has continued to maintain liaison between the Committee of Malayan Latex Technologists and the British Standards Institution Sub Committee RUC/10/7, which deals with methods of latex testing. Contact has also been maintained with Committee D-11, Sub-Committees of the American Society for Testing Materials, which deal with latex and with raw rubber. Exchange of views has been continued with sister Research Institutes, and with the International Rubber Research Board and the International Rubber Development Committee, a member of the staff on leave, Dr W. A. Southorn, having attended meetings in Delft in July and London in November, as well as visiting the Institut Francais du Caoutchouc in Paris for research discussions.

Published contributions to a recognised journal were as follows:

'A Medium for the Cultivation of Bacteria from Hevea Latex' and 'Bacterial Culture Media from Waste Hevea Latex Sera by D. H. Taysum in the *Journal of Applied Bacteriology*.

Articles published in the *Planters' Bulletin* comprised:

'Paper Bag Packing'; 'A Note on Stimulant Treatment — A Caution'; 'Weights and Measures'; 'A note on Quality of Latex Concentrate'; 'Chemical Division Advisory Work, 1955'; 'Cleanliness in the Factory'; 'Editorial — Chemical Division Advisory Service'; 'Special Rubbers'; 'Recent Advances with Latex'; 'Skim Rubber'; 'Antibiotics from Skim Serum'.

In connection with Technically Classified rubber, the following documents were prepared and circulated:

TC Bulletin No. 35 — World Output of Technically Classified Natural Rubber

TC Notes No. 1/56 — Present Position of T.C. Rubber in Malaya

TC Notes No. 2/56 — Marketing of Technically Classified Rubber

RESEARCH INVESTIGATIONS

NON-RUBBER CONSTITUENTS

Sterile Tapping

Earlier attempts to obtain latex from the tree under sterile conditions utilised a small apparatus, which did not permit tapping in the normal manner but depended on stabbing or pricking to open latex vessels. A much larger apparatus has now been constructed which surrounds the tree with a cubic box, about five feet high, and permits normal tapping. The interior of the box is sterilised by ultra-violet irradiation; manipulation inside the box is carried out through rubber bellows terminating in gloves, which are mounted in a heavy perspex window, set in one side of the box. Latex after collection in sterile vessels is removed through a specially designed air lock.

Collections of latex under these conditions proved not to be sterile. It was quickly established, however, that the source of contamination was the latex vessels themselves, which were shown to be infected to a depth of some one-third of an inch. By making a heavy tapping cut so as to remove the infected vessels, sterile latex was obtained. Bacterial control has also been achieved by injecting bactericides into the latex vessels accompanied by swabbing the tapping cut with a bactericidal detergent wash.

Latex obtained under these conditions showed a high dry rubber content, values over 50% being recorded. The flow was also prolonged and yielded much more dry rubber than usual; up to five times the expected amount was observed. At present it has not been established to what extent the increased yield is due to the well known phenomena of flow stimulation by mechanical and chemical means and to what extent it is due to removal of bacterial infection from the latex vessels. These aspects are now being studied. Patent protection has been sought for operating tapping processes which employ sterilisation of the tapping cut.

Bacterial Counts in Latex

Although counts of viable bacteria are proving a very useful tool for controlling the quality of latex concentrate production, it has now become apparent that future behaviour of latex cannot always be completely accounted for by the number of living cells present at any given time. This is partly due to the fact that bacteria are living organisms and may proliferate under favourable conditions or decrease in less favourable ones. Another explanation is that dead bacterial cells may play a part in the changes proceeding in latex concentrates on storage. This is thought to be a possible explanation of some anomalous observations on volatile fatty acid formation, which in a few cases proceeds rapidly although viable bacterial counts would appear to be low. Dead bacterial cells may provide a source of acid producing enzymes, enzyme activators or suitable substances for naturally occurring enzymes.

It is thus of considerable importance to know to what extent dead bacterial cells are likely to influence behaviour of latex concentrate on storage. Attention is now being given to developing satisfactory methods of total counts for bacteria in latex, including both viable and dead cells; for this purpose phase contrast, fluorescence and interference microscopy are being employed. Of these the interference microscope appears very promising, but is too involved to operate as a routine method. It is probable that sedimentation combined with fluorescence microscopy will provide the most accurate estimate.

Aldolase

In 1955, we received a request from Birmingham University for increased supplies of freeze dried bottom fraction, obtained by high speed centrifugation of hevea latex; it had been established that the bottom fraction showed aldolase activity and it was required to investigate the matter further. It was, however, quite impracticable to produce the quantity of material required and we decided to make a brief examination of different latex fractions for aldolase activity, with the hope that a richer source of the enzyme might be found.

Fresh serum separated by high speed centrifuging (Serum-C) was soon found to display very marked aldolase activity. Examination of freeze-dried fractions showed that freeze dried serum-C was also highly active and that on a weight basis freeze-dried serum-F (serum-F is obtained by freezing and thawing whole latex) was roughly half as active as freeze-dried serum C. The activity of unfractionated freeze-dried bottom fraction could not be accurately assessed by the methods used (adapted from those of Gascoigne working at Birmingham University). It was, however, possible to demonstrate that the activity of bottom fraction was only a very small fraction of that of serum-C, and was much less even than that of serum-F on a weight-for-weight basis.

This showed that of the three conventional freeze-dried latex fractions, bottom fraction was the least suitable for an extended study of aldolase activity. It also followed beyond reasonable doubt that in fresh latex the enzyme is located in the serum phase rather than in the sedimentable particles. The slight activity of freeze-dried bottom fraction is possibly due to occluded serum present in this fraction.

Experiments on the fractionation of fresh serum-C with acetone at low temperatures showed that the enzyme was recoverable in high yield in the fraction precipitated between 30% and 50% concentration of acetone. The enzyme appeared to be readily soluble in water, and could be concentrated further by the elimination of water insoluble matter from the acetone precipitate. The aqueous solution of the enzyme could be then freeze-dried with little loss of activity. A preparation made in this way showed about eight times the activity of freeze-dried serum-C, on a weight basis, and was free of excess inorganic phosphate, hygroscopic material and other substances which had been found to interfere with the assay of aldolase activity in unfractionated serum-C. The preparation of large quantities of such an aldolase concentrate for export to Birmingham was unfortunately not practicable since the process, though basically rather simple, would be very time consuming and costly if operated as a routine on a large scale.

Our observation that freeze-dried serum-C has high aldolase activity has been confirmed by workers at the University, and it now appears that this material or freeze-dried serum-F will be a cheaper and preferable source for further studies on aldolase.

Development of Centrifugation Techniques

An investigation of the osmotic behaviour of the sedimentable phase of fresh latex is in progress. The current working theory in regard to this phase is that it contains particles bounded by a membrane and filled by a solution which includes certain enzymes. This belief is based on the description of 'lutoids' by workers at Bogor, on the fact that bottom fraction prepared from latex by ultra-centrifugation is semi-solid, despite a water content of about 90% w/w, and on the observation that several water soluble enzymes, notably polyphenoloxidase and dopa decarboxylase are sedimented with the bottom fraction during ultracentrifugation. These enzymes are released in solution along with a substantial volume of liquid when bottom fraction is frozen and thawed, presumably because this process destroys a particulate structure.

The present investigation is intended to test this theory further and to aid in the development of a medium in which bottom fraction might be resuspended and washed without destroying its structure.

Work this year has dealt mainly with the material sedimented from latex at low speeds, described as 'yellow fraction' by our colleagues at Bogor, but for which we prefer the term 'heavy fraction'. On diluting heavy fraction with distilled water, flocculation occurs and certain reactions set in, for example surface darkening, suggesting activation of polyphenoloxidase. By using sugar solutions of suitable tonicity, however, it has been established that flocculation can be avoided, and other changes greatly delayed. It appears that in hypotonic solutions lysis of the 'particles' occurs releasing their contents.

Suspension of heavy fraction in sugar solutions of similar tonicity but different density (mannitol and sucrose) indicated that the density of the particles (between 1.02 and 1.06 gm per ml at 31°C) was low compared with that usually shown by sub-cellular particles from plant tissues.

Polyphenoloxidase and Other Phenolases

Work previously reported showed the presence in latex of an enzyme system oxidising polyphenols such as catechol. The system seemed largely confined to the particulate phase associated with bottom fraction. It has now been established that the oxidising system can attack monophenols as well, the enzyme responsible being present in bottom fraction. It is inhibited in whole latex, and is either inhibited or absent in serum-C.

Samples of bottom fraction darken on exposure to air and it seemed likely that latex contains a natural substrate for enzymes of the polyphenoloxidase type. It has now been established that several such substrates occur in latex, although none has been identified as yet; the amounts present appear to be very small and would render isolation difficult.

It has further been shown that the different degrees of darkening observed in latices from different sources are due, in part at least, to different levels of concentration of natural substrates for polyphenoloxidase.

Carboxylase

Evidence has been obtained that the pyruvic carboxylase of serum-C can be sedimented in the Spinco preparative ultracentrifuge at high g-values. Thus there is appreciable sedimentation in a field averaging 105,000 g applied for 45 minutes. This implies that the enzyme is attached to very small sub-cellular particles, or that it is a soluble protein of unusually high molecular weight. The second alternative seems the more likely and it is interesting to compare the observation of Singer (1952) working at Western Reserve University, Cleveland, that carboxylase of wheat germ also has a high sedimentation velocity and a molecular weight above 1,000,000.

Hydrogen Sulphide Formation by Latex

It has been established that fresh latex evolves hydrogen sulphide; there is evidence that this is due to an enzyme system in the serum phase. The reaction proceeds in latex collected under sterile conditions and treated with antibiotics, and is thus not attributable to the activities of contaminating bacteria. Cysteine is a possible source of the gas, but there may be other natural precursors.

Serum Proteins

Investigations of latex proteins have been made at B.R.P.R.A. on freeze-dried samples prepared in Malaya, comprising serum-C, serum-F and bottom fraction. A method employing paper electrophoresis was developed at Welwyn to resolve the protein mixtures into their components.

It was decided to carry this investigation further in Malaya by examining the components of proteins found in the serum of latex from different clones, with the hope that any differences observed could be correlated with technological behaviour.

Attempts were made to reproduce some of the B.R.P.R.A. results using an apparatus copied from the one at Welwyn. The electrograms obtained were unsatisfactory and repeated trials failed to give any improvement. Different types of apparatus were then tried and finally a model of the 'hanging strip' type was constructed. This has given satisfactory results with extracts prepared from freeze-dried bottom fraction, but was not entirely satisfactory for use with serum.

It has been demonstrated that aqueous extracts of latex bottom fraction are resolvable into six components, two anionic and four cationic. Three of the cationic components appeared somewhat difficult to separate; it is interesting to record that polyphenoloxidase activity appeared to be associated with each of these three components. The relation between the six proteins observed at R.R.I. and the seven described by B.R.P.R.A. as occurring in serum-C has yet to be established.

The bottom fractions from four clonal latices were examined; they showed components indistinguishable from those described above, with one exception, Tjir 1, samples of which gave evidence of a seventh component, cationic in nature. This remains to be confirmed by further observations.

LATEX CHEMISTRY & TECHNOLOGY

Mechanism of Coagulation

Much of the work on coagulation has been in abeyance during the year, owing to the absence on leave of the officer concerned, but it has been possible to continue observations on the coagulation of latices containing anticoagulants, attention having been given to conditions likely to be encountered in operating a continuous process of converting latex to dry rubber.

It has been shown that each anticoagulant/coagulant combination has its own pattern of coagulation behaviour, particularly in regard to the effect of pH of coagulation upon coagulum strength. For most systems, however, coagulation behaviour was unpredictable during the first six hours after adding the anticoagulant. Thereafter, behaviour followed more definite lines and was more uniform. Of the combinations tried, formalin as anticoagulant with sulphuric acid as coagulant was the cheapest which would give the required behaviour, viz., storage of the latex up to 30 hours and a reasonable strength of coagulum on acidifying.

Microscopy of Latex

Study of latex using an interference microscope has confirmed earlier observations of workers in Indonesia, that particulate bodies, called by them 'lutoids', occur in latex, and show plasmolysis on addition of ammonia. The membranes of these 'cells' persist after ammoniation and final destruction of the lutoids may take several months.

Preservation of Field Latex

Most reagents which are used for the preservation of latex concentrates also preserve field latex, but often have undesirable effects upon coagulation behaviour, colour or other properties of the final sheet or crepe prepared. A study of certain antibiotics, sulphonamide derivatives and ammonium borate has now been completed, and shows each of these substances as satisfactory for short term preservation before preparing sheet rubber. Compared with customary anticoagulants such as ammonia, formaldehyde, and sodium sulphite, however, the cost of antibiotics and sulphonamides is too high; ammonium borate may find commercial application, as it appears a useful short term preservative.

Preservation of Latex Concentrate

The development of VFA in latices which appear to show low counts of viable bacteria, has led to the view that enzymes from dead cells may be responsible in part for the acid formation. This view could also account for the puzzling behaviour of many powerful bactericides, which although lethal to bacteria, do not preserve latex, on the grounds that they do not act as poisoners for enzymes which produce VFA. It has now been established that VFA formation can be inhibited by a number of enzyme poisoners including copper, silver, zinc, nickel, semicarbazide, sodium fluoride, iodoacetic acid, etc. Application for patent protection has been made in respect of latex preservation utilising these methods. The basic needs for preservation appear to be a bactericide and an enzyme poisoner together with low concentration of alkali, such as 0.2% ammonia. Many such combinations have proved effective. The most suitable enzyme poisoner examined so far is zinc oxide, used at a 0.1% level on the latex concentrate. A wide variety of bactericides can be employed including chlorinated phenols, boric acid, many organic accelerators of sulphur vulcanisation (e.g. mercaptobenzthiazole, diphenylguanidine, cyclohexyl benzthiazyl sulphenamide, etc.) antibiotics, sulphonamide derivatives, etc. The bactericide is usually employed at the 0.1% level. Further work is in hand to determine technological characteristics of these latices.

Another preservative system which is also being examined and appears satisfactory is the use of selenium dimethyl dithiocarbamate with ammonia and lauric acid.

Low ammonia latex concentrates preserved with boric and lauric acids have been further studied. Reports from the U.K. and Australia indicate that technological properties for foam rubber manufacture are satisfactory; the latex has a high KOH No. because of the added boric acid present, although this may not prove to be a disadvantage. It is hoped to obtain further evaluation by manufacturers in the near future.

A number of substances have been examined for bactericidal properties in respect of bacteria occurring in latex. The more promising ones are now being tested for use as a latex preservative. In this connection cooperation has been sought from two companies in the U.K. concerned with the production of bactericidal agents.

Maturation of Latex Concentrates

It has been known for some time that during maturation freshly prepared concentrates of latex containing ammonia, absorb considerable quantities of oxygen. In earlier reports, we have described experiments in which the rate of maturation has been influenced by withholding or providing supplies of oxygen. It has also been recorded that systems giving a high redox potential promote maturation, whereas those giving a low redox potential retard the changes occurring.

We have now demonstrated that by agitation with air, the rate of maturation can be greatly increased, concentrates often showing mechanical stability figures of three times the value in a given maturation period. By controlling availability of air and amount of agitation of the latex, considerable degree of control can be exercised in bringing concentrates comparatively rapidly to the required mechanical stability. In actual practice, all that was found necessary was to maintain a gentle movement in the latex such that all parts of it are frequently brought into contact with the air. Bubbling is considered undesirable owing to removal of ammonia and froth formation.

It was found, however, that after a period of aeration, dried films of the latex were slightly soft and showed inferior oven and sunlight ageing. This is thought to be due to the formation of hydroperoxy groups on the rubber hydrocarbon. In some cases, it has been observed that after a further period of storage in closed vessels, the inferior ageing characteristics were no longer apparent, presumably due to destruction of the hydroperoxides under anaerobic conditions of storage.

Experiments showed that the inferior ageing characteristics can be removed by the addition to the latex of reagents likely to destroy hydroperoxide groups such as hydroquinone, and certain amines (e.g. tetramethylene pentamine, benzidine, m-phenylene diamine, etc.). These materials had no adverse effect upon the rate of increase of mechanical stability. Sequestering agents were also found to have a beneficial effect; in general they markedly reduced the amount of oxygen absorbed, and inhibited deterioration of the dry rubber on ageing, actually conferring greater resistance to oxidation than that shown by rubber from unaerated latices. Of the sequestering agents tried, ethylene diamine tetra-acetic acid, hydroxyethyl ethylene diamine triacetic acid and sodium imino diacetic acid were found very effective.

This work has obvious commercial applications and patent protection is being sought.

It is interesting to record that in the presence of freeze dried cobra venom it has been possible to increase the mechanical stability of freshly ammoniated field latex by as much as 800 seconds in about one hour. This observation has not yet been investigated, but it is thought probable that enzymic splitting of phosphatides to yield highly surface active products may be the explanation.

Foam Rubber

The bulk of latex concentrate is used in the manufacture of foam rubber. It is therefore, important that R.R.I. should be acquainted with methods of making foam and equipped with testing facilities in order to assess the suitability of a given concentrate for preparing foam rubber. During the past year and a half methods of preparing foam rubber have been studied and we can now examine the suitability of latices for small scale production.

The first approach was to study variability of latex for foam manufacture and we were fortunate in finding latices on the Sungei Buloh Experiment Station which showed widely divergent behaviour. These differences appear to be associated with surface activity and are being further investigated.

The anomalies studied in this work may not of course be typical of those occurring in all latices and a broad survey of concentrates produced in Malaya is planned in the near future.

Test Procedures

A method for estimating zinc in latex has been studied, using an ashing procedure followed by titration with potassium ferrocyanide; some modifications of the usual method have been found advantageous.

Attempts have also been made to estimate boric acid in latex, using a number of different methods. At present none is completely satisfactory and the problem is still being investigated.

RUBBER CHEMISTRY AND TECHNOLOGY

Rubber Hydrocarbon

In the course of our investigations on the drying of coagulum, it was observed that drying at high humidity appeared to bring about enhanced oxidative deterioration of the rubber, as compared with drying at low humidity. It has also been observed that processes which give rise to more rapid maturation of latex concentrates often involve changes in the rubber which produce lower resistance to oxidation, particularly on heating the dry rubber.

Experiments with natural rubber and a number of synthetic ones including neoprene and hycar, demonstrated that storage or heating in dry air or *in vacuo* gave definite increase in hardness, suggesting that the rubber had become more highly crosslinked. A possible explanation of these observations is the formation of hydroperoxide groups at certain points on the hydrocarbon chain, which under dry conditions proceed to give cross-links in the rubber and under wet conditions result in chain scission.

In order to verify this hypothesis attempts were made to remove hydroperoxide groups by treating the rubber with suitable reagents. Both polyamines and hydroquinones resulted in rubber showing a higher Mooney viscosity and much enhanced resistance to oxidation, suggesting the presence of hydroperoxide groups which give rise to free radicals and cross-linking in the presence of activating agents.

If such hydroperoxy groups are present, it should be possible to utilise them to induce polymerisation of vinyl monomers. Trial polymerisations using methyl methacrylate demonstrated that latices which had been allowed to oxidise, either by storage or by deliberate aeration, had marked polymerisation activity, as shown by increase in temperature subsequent upon the addition of monomer and amine and the formation of rubber methyl methacrylate graft polymers. The reactivity correlated very well with the degree of aeration of the latices. Reactivity could be removed by subjecting the latices to autoclaving at 100 lb steam, when presumably, the hydroperoxy groups were destroyed. It is of interest to note that serum from reactive latices showed no activity, which thus appeared to be associated with the rubber particles.

At present our observations suggest that by exposing latex to contact with air, hydroperoxy groups can be produced which are associated with the polyisoprene chain. By regulating the degree of aeration the number of reactive centres can be controlled. Such reactive centres may be of considerable value in the production of graft copolymers, and may permit some control of the nature of graft produced. Application is being made for a patent covering these observations.

A.S.T.M. Proposed Specification for No. 1 Quality Rubber

In June, 1955, the American Society for Testing Materials proposed a specification for No. 1 quality sheet and crepe rubber, and called for views on the limits which should be set for certain properties.

We undertook a series of small surveys of Malayan produced No. 1 sheet and crepe, covering in all some 650 samples. Two important conclusions were drawn from this work. In the first place it was shown that the limits proposed by A.S.T.M. were in some cases incorrectly placed, and resulted in large proportions of Malayan No. 1 rubbers not conforming to the proposed specification. Secondly, it was established

that small surveys of the size undertaken are unlikely to yield a reliable picture of Malayan rubber production. Larger surveys, in which great care is taken in selecting samples appear to be essential if a sound assessment is to be obtained.

SPECIAL AND MODIFIED RUBBERS

Superior Processing (SP) Rubbers

Since SP crepe rubber met with a favourable response from manufacturers, attempts have been made to put SP sheet on the market. This has been successfully accomplished and some 15 tons of SP sheet have been prepared and shipped during the latter half of the year. Means of cheapening production have been studied, so far without any outstanding success, although small reductions in cost are thought possible.

A different method of vulcanisation was examined, using cumene hydroperoxide and tetraethylenepentamine as the cross-linking system. Vulcanisation was carried out at room temperature and appeared to be an attractive proposition. Unfortunately the rubber produced showed SP characteristics in unfilled stocks, but not in black and other filled stocks. This difficulty was overcome by vulcanising with ditertiary butyl peroxide under 100 lb steam pressure; from this latex rubbers showing good all round SP properties could be prepared. A method employing autoclave heating is not so attractive however, and it is doubtful whether development to a commercial scale will prove successful.

Attempts to produce SP rubbers from the skim discharged in the course of preparing vulcanised latex concentrate were not successful, owing to the low degree of vulcanisation obtaining in the skim rubber particles.

One of the difficulties with SP rubbers has been that their production has been confined to estates. Consideration has now been given to the preparation of lower grade rubbers having SP characteristics. In this connection, a most interesting development is the possibility of utilising a masterbatch containing a high proportion of vulcanised rubber. Such masterbatches have been prepared containing as little as 10% raw with 90% vulcanised rubber, and are obtained as a crumb. Application of the masterbatch has been made in two different ways.

In the first instance, the coagulum formed in preparing the masterbatch is milled wet with scrap rubber to give SP remilled rubber. It is anticipated that this process could be operated on estates or in remilling factories, thus producing a new commercial grade of remilled rubbers having SP characteristics. The second method employs the dry crumb which can be milled dry into any grade of rubber to which it confers SP behaviour. Such an operation would preferably be carried out by the manufacturer of rubber goods in his factory and entails the marketing of SP masterbatch as a new variety of rubber. At present both methods work satisfactorily at the laboratory level, but confirmation by larger scale trials is needed. Economic considerations have also to be taken into account. Application for patent protection is being made.

From the technical point of view, further properties of SP rubbers have been established. It is found for instance that these rubbers break down more slowly during mastication than normal raw rubbers. On the other hand, tyre tread compounds prepared with high viscosity SP rubber show a swell similar to that given by treads from low viscosity rubber. This gives an advantage in that accurate extrusion can be obtained without resort to so high a degree of breakdown by mastication.

It has been found that the extrusion swell of SP rubbers compounded as unfilled and as loaded stocks, do not correlate. It seems preferable to carry out tests on filled stocks and at present they are carried out on stocks prepared using a constant mixing cycle, irrespective of the Mooney value of the raw rubber.

Rubber-Lignin Masterbatch

An attempt has been made to round off the work on rubber-lignin masterbatch and to prepare an assessment of the present situation.

The masterbatch has been prepared by a batch and by a continuous process, the merits of the two being compared. On the small scale employed, which produced about one hundredweight a day, no significant difference in the cost of operating the two processes was found. Formic acid was found to be too costly to use and sulphuric acid was preferred. Details of the cost which would be met by rubber manufacturers in using rubber lignin are now being finalised. It is hoped to submit our findings in respect of technical properties and cost to the manufacturing industry for an assessment of the likely value of rubber-lignin as a raw material. Further investigation will depend upon the result of manufacturers' evaluation.

Graft Polymers

The introduction of synthetic monomers into rubber hydrocarbon forms part of the research programme of B.R.P.R.A.; work on similar lines at R.R.I. has been small in volume and complementary in nature, in so far as it has been confined to work which can only be carried out in the East.

A difficulty in producing materials derived from natural rubber is the lack of chemical groups with which added monomers can react. In consequence one line of approach is to attempt the incorporation of reactive groups into the rubber hydrocarbon. Attempts at B.R.P.R.A. to incorporate at the latex stage monomers with reactive groups such as acrylic and methacrylic acid were unsuccessful, owing to instability of the latex. Experiments at R.R.I., however, have been more successful, presumably owing to the different stabilising system naturally present in fresh and freshly ammoniated latex as compared with latex concentrate available in the U.K.

A peroxide-amine polymerisation system has been used to produce the graft polymers, but so far the yield has been small. The grafted rubbers can be vulcanised using suitable ingredients and yield a rubber with improved oil resistance.

PREPARATION AND PRESENTATION

Bactericidal Washes for Use in Latex Factories

A factory experiment extending over a period of four months has been carried out to determine the value of different methods of factory cleansing upon the quality of latex concentrate. The trials were statistically planned to cover three treatments, comprising normal washing of factory utensils, pipelines, tanks, etc., very thorough washing with water and very thorough washing followed by a rinse with bactericidal solutions. The bactericides employed were changed daily to avoid the development of resistant strains of bacteria; they consisted of (a) chlorinated trisodium phosphate, (b) formaldehyde and Teepol, and (c) dichloro m-xyleneol, sodium hydroxide and Teepol. As well as carrying out counts of viable bacteria, technological tests were carried out on the latex concentrate up to three months after preparation.

Full results are not yet available, so that analysis of the data is not yet possible. It is apparent, however, that build up of bacterial populations in the factory requires many weeks and likewise it takes several days for the full effect of thorough cleansing to become apparent. The results leave no doubt that if very thorough cleansing with water is maintained, a marked reduction is made in the number of viable bacteria

found in the concentrate produced as compared with normal factory washing. The difference between very thorough washing with water only and thorough washing followed by bactericidal solutions is not so marked and we await further analysis of the data before drawing conclusions.

Drying of Rubber

Although the detailed investigation of the effects of temperature and relative humidity on the drying of sheets has not yet been undertaken, much supporting work has been carried out and the method of operating the drying tunnel for the crucial experiments has now been finalised. In the course of these preliminary studies a number of observations have been made, which are of considerable interest.

Drying of rubber sheets has been regarded as occurring in three separate phases; our experimental results, in particular temperature measurements, confirm this. In the first instance water is removed from the surface of the sheet, the temperature remaining constant near the wet bulb value. This is followed by a stage in which the temperature rises rapidly, and merges into a third stage when the temperature remains almost constant, gradually approaching the dry bulb temperature.

Air speed plays an important part in determining the rate of water removal during the first two stages, which, although accounting for removal of two-thirds of the water are of short duration. The third stage which occupies the major part of the drying time, appears to be unaffected by rate of air flow within the range observed, 60 to 300 feet a minute. In an R.R.I. type smokehouse the rate of passage of air is considerably less.

The opinion has often been expressed that drying at a comparatively high humidity avoids the formation of an impermeable skin at the surface of the sheet, and thus accelerates drying. None of the data so far collected support this view. Temperature, however, has a marked effect upon the overall drying rate, the temperature coefficient being so high that the rate is tripled by increasing the temperature from 140°F to 190°F.

A brief examination was made of the effect of high temperature and high humidity upon the quality of the rubber hydrocarbon. At high temperatures softer rubbers showing a higher degree of cross-linking were produced. No significant degradation occurred during subsequent storage at room temperature for three months. Rubbers dried at 200°F showed inferior oven ageing in the raw state compared with those dried at 140°F. When a high water content as well as a high temperature was employed, much softer rubbers with inferior oven ageing characteristics were obtained.

In spite of employing a standard process for preparation, considerable differences in drying time of supposed identical sheets has been experienced from time to time. Small variations in the pH of coagulation were found to be without appreciable effect, there being no correlation with drying time over the range 3.8 to 4.5. An anticoagulant (ammonia) has been employed to ensure as good a stage of preservation as possible and so avoid variations on this account. There was some evidence that time of standing after adding the anticoagulant and before adding the acid may influence drying rate, and more uniform sheets are now being produced by employing simultaneous coagulation of all sheets required for a given experiment.

Blisters in Sheet

Sheet rubber as prepared on most estates will blister if the temperature exceeds 130°F during the first day of drying. This is a severe limitation of temperature and would obviously be better avoided. Attempts have been made to determine the mechanism of blister formation. Results are not conclusive but indicate that the

blisters are formed from gases dissolved in the serum, which are released as the temperature rises. If the outside of the sheet is sufficiently dry to prevent ready escape of the gases, bubbles will form within the sheet.

If coagulum is steamed before drying, the gases are released and no blister formation occurs, although blemishes occur which are presumably points where release of gas has occurred.

An analysis of the gas contained inside the blisters after drying showed it to be air with some carbon dioxide. It is of interest to note that artificial blisters produced by injection of partially dried coagulum with carbon dioxide, showed a similar gas analysis after drying.

Oil-Fired Drier

Preliminary trials with an oil-fired heater have been made, which utilises products of combustion directly for heating a conventional drying shed. The fuel employed was diesoline and after an initial warming up period of half-an-hour, good clean combustion was obtained. Sheet dried under these conditions showed no undesirable characteristics; acetone extract and sulphur contents were normal.

The temperatures attained so far have not been as high as required and further trials are in hand. Even so the heater appears promising and may provide a cheap and satisfactory means of heating drying sheds.

ADVISORY & DEVELOPMENT WORK

Shortage of staff has been more acute in 1956 than in 1955, due to the absence on leave of the Advisory Officer. In consequence it has been possible to deal only with problems of immediate practical importance, although every effort has been made to maintain replies to enquiries and visits to estates at the customary level. Our records show a small reduction in enquiries concerning sheet and crepe rubber, but those concerning latex remained at the same level as for 1955. Details of correspondence, visits, samples tested, etc. are as follows:

	<i>Letters received</i>		<i>Letters despatched</i>	
	1955	1956	1955	1956
Sheet production	287	247	358	289
Crepe rubber production	397	324	423	396
Latex production	778	758	1,034	1,066
Other processes	89	140	165	169
Classification of rubber	2,153	1,619	610	965
Research and others	376	454	582	589
Total	4,080	3,542	3,172	3,474
Visits	1955	1956		
Advisory	138	94		
Experiment Station	384	433		
Research and others	39	20		
Interviews	431	329		
Lectures to Planters' Associations	2	2		

Samples examined:	1955	1956
Latex hydrometers	97	141
Customs' samples for d.r.c.	690	510
Latex samples	1,421	1,275
Sodium bisulphite	11	4
Coagulants	—	11
Defects in sheet and crepe	218	169
Cyclised rubber	—	159
SP rubber	—	77
T.C.R.	27,672	24,368
Others	94	188

Sheet

Many estates have shown interest in smokehouses, some extending their drying facilities to cope with increased crops following replanting, some improving efficiency of production by modernising existing equipment, and others rehabilitating factory facilities against reversion to sheet production when sales of liquid latex become uneconomic. Tunnel type smokehouses are generally preferred unless the site has a high water table, when Subur type houses with raised flues are more suitable.

A few estates have adopted oil-fired burners with forced air draught for heating drying sheds and considerable interest was aroused by a publication in our *Planters' Bulletin* giving details of a successful drying shed at Senawang Estate.

Fermentation bubbles in sheet have again been successfully combated by using formaldehyde. A few cases of pre-coagulation in latex from Glenshiel I have been reported and have been difficult to counteract. A completely successful treatment for this problem has yet to be worked out.

Crepe

The high premium obtainable for pale crepe during the year resulted in considerable interest in the preparation of this form of rubber. The R.R.I. bleaching process continues to be used extensively and supplies of the bleaching agent (Emulsion A concentrate) to estates have been regularly checked for quality in order to avoid the use of deteriorated material. Advice has been given on avoiding defects such as poor ply adhesion, development of spot, fungal growth, etc.

It is interesting to note that a few large producers have installed crepe drying tunnels, heated by a forced draught of warm air, the source of heat being oil-fired burners, which operate a heat exchanger.

Latex Concentrate

Owing to the comparatively poor market for latex concentrate, production in Malaya during 1956 has been less than anticipated. Even so, latex production continued to be the major source of enquiries received during the year.

Interest in the testing of latex concentrates has been considerable, advice on the setting up of testing laboratories and demonstrations of test procedures having been given.

The volatile fatty acid test continues to be a most valuable guide in controlling latex quality, in respect of both field latex and latex concentrate. During the year, this has been supplemented by counts of viable bacteria present in latex and a bacterial laboratory to handle routine counts has been set up at R.R.I. headquarters.

Malayan concentrate shows a wide range in bacterial counts from one cell per millilitre to over a million. The species of bacteria found in different localities are similar. The principal sources of bacterial infection have been investigated in several factories. It is apparent that there are wide variations in the degree of contamination of field latices coming into the factory, which depends largely upon cleanliness of the collecting equipment and early ammoniation in the field. Apart from this, however, the factory itself is usually a major source of infection, unless scrupulous care is taken in maintaining dairy-like cleanliness. Further sources of infection are road and rail tankers, and even reception and storage tanks at port installations. It is of interest to note that in the few bulk shipments so far examined, little or no contamination from ships' tanks has been detected.

In attempts to improve cleanliness throughout the course of production, we have investigated the use of bactericides in washes for factories, the use of self-sterilising paints and of 0.7% ortho phenyl phenol in wax linings for tanks, all of which have shown promise.

An investigation of concentrates prepared using latex from Glenshiel 1 showed that high proportions of this latex brought about a marked lowering in quality. A maximum of 15% was found tolerable, when mixed with seedling latex and that from other well-established clones; even so, close technical control was required to produce good quality concentrate.

Cyclised Rubber

During the year 159 samples of commercially produced cyclised rubber were examined, representing some 80 tons production.

Rubber Powder

Samples of a commercially produced unvulcanised rubber powder have been examined and shown to behave rather differently from vulcanised powders when heated with bitumen. Owing to lack of background experience against which to assess the material, it was not possible by this means to estimate with any certainty the value of the material for use in road carpets, although its properties appeared promising.

Purified Rubbers

As recorded in the previous *Annual Report*, four tons of a partially purified crepe were prepared for evaluation by a British Chemical manufacturer. The reports were satisfactory and an enquiry for further supplies has been passed on to a local producer.

Further samples of more highly purified rubbers have been forwarded to the U.K. for laboratory evaluation and two hundredweights of a purified SP rubber sent for trial in response to a request from a British Cable manufacturer.

Superior Processing Rubber

SP crepe has been produced commercially throughout the year, 84 samples representing 54 tons having been tested to ensure maintenance of good quality. Other producers have shown interest in preparing SP crepe, but no further licences have been granted.

At the Experiment Station factory, we have successfully prepared SP sheet, both smoked and air-dried. At the close of the year 14 tons of SP smoked sheet and about 1 ton of SP air-dried sheet had been produced for shipment overseas. Arrangements have been made for the sale of this material through agents in London and New York at a premium of one penny sterling per pound above the current price of the corresponding grade, i.e. RSS 1 or air-dried sheet.

Packing

A consignment of specially clean pale crepe packed in experimental wrappers was shipped with stowage at the bottom of the ship's hold. The condition of the bales, each about 120 lb, was observed on receipt in the U.K. In general, paper bag packing was found satisfactory, although inner wrappers of a fairly tough material such as polythene were preferable, if complete freedom from contamination is required.

Technically Classified Rubber

The number of estates participating in the Technical Classification Scheme has decreased slightly throughout the year to a total of just under 100 estates towards the close. In consequence the output of T.C. rubber from estates has fallen a little, and is estimated at about 30,000 tons for the year; this figure is made up as follows:

ESTIMATED OUTPUT OF RUBBER FROM ESTATES USING R.R.I.
FACILITIES FOR TECHNICAL TESTING

R.M.A. type	Technical Classification			Total
	Red Circle	Yellow Circle	Blue Circle	
RSS 1 & 1X	1,350	22,600	3,600	27,550
RSS 2	10	400	10	420
RSS 3	Nil	50	Nil	50
RSS 4	50	100	Nil	150
Clippings	Nil	70	Nil	70
Pale crepe	150	Nil	Nil	150
Brown crepe	Nil	120	160	280
Air dried sheet	500	800	100	1,400
<i>Total</i>	2,060	24,140	3,870	30,070

Little interest has been shown by packing houses in classification, production for the year being 670 tons, as follows:

RUBBER FROM PACKING HOUSES CLASSIFIED DURING 1956

R.M.A. type	Technical Classification			Total
	Red Circle	Yellow Circle	Blue Circle	
RSS 1	48.0	261.1	244.6	553.7
RSS 2	Nil	12.0	27.0	39.0
RSS 3	Nil	Nil	74.0	74.0
Brown crepe	Nil	2.8	Nil	2.8
<i>Total</i>	48.0	275.9	345.6	669.5

Remilling factories have shown no interest in classification, and no rubber has been dealt with from this source.

As far as can be ascertained, manufacturers continue to show most interest in yellow class rubbers, which have vulcanisation characteristics in the middle range. A small demand for fast curing blue rubber has been reported, but no demand for slow curing red rubber. Most estates do not mark their produce when it is classified as red; some but not all, take advantage of the methods recommended by R.R.I. to convert red class rubber into yellow class.

During the year the Rubber Manufacturers' Association of New York issued the results of a questionnaire seeking information from manufacturers regarding potential requirements for Technically Classified rubber. The figures given indicated a comparatively large total demand, about 100,000 tons; unfortunately the major part of this requirement comprised grades lower than those normally produced on estates. It seems evident that an unfulfilled demand for T.C. lower grade rubbers still exists.

W. G. WREN
Head of Chemical Division

Smallholders' Advisory Service

Mr L. R. Davidson, Mr J. M. F. Greenwood and Inche Shamsuddin bin Yub Ahmad were on duty throughout the year. Mr J. W. L. Bevan proceeded on home leave on 6 March and subsequently resigned his appointment. Mr J. G. Samuel completed examinations for the B.Sc.(Agric.) degree of Gauhati University in December and returned to the Rubber Research Institute to resume duty on 27 December. He was appointed Assistant Smallholders' Advisory Officer on the Graduate Assistant scale with effect from this date.

In June Inche Mohd Johar bin Mohd Rashid was promoted Senior Rubber Instructor and took over the supervision of Junior Rubber Instructors and Rubber Demonstrators in Kelantan. In August Mr Wong Mun Yun was similarly promoted to supervise the work of field staff throughout Negri Sembilan and Malacca.

During the year three Rubber Instructors resigned to join the Rubber Industry (Replanting) Board and one was appointed Rubber Development Officer in the Sarawak Government Service. Two Rubber Instructors joined plantation companies. In contrast only one new graduate of the College of Agriculture, an R.R.I. Scholar, was available to join the Service and our complement of Rubber Instructors (including Senior Rubber Instructors) declined from thirtyone to twentysix. Four Rubber Instructors were required to transfer to new stations during the year. Two of these were in completion of long standing arrangements and two were urgent adjustments to staff losses.

Provision for two new R.R.I. Scholarships at the College of Agriculture had been approved for 1956; owing to the demand for places for Government nominees from Malaya and adjacent territories only one new entry from the R.R.I. could be accepted by the College and the scholarship was awarded to a young Chinese who had attended the training course for Junior Rubber Instructors.

This difficulty of securing basic training in agriculture and the related sciences for replacement staff for the SHAS serves to emphasize the inadequacy of provisions for technical training in this country. Schemes of planned development and economic aid for peasant farmers are falling short of the results which should be expected and are liable to fail for lack of sound technical supervision. Yet the cost of expanding necessary educational facilities is unlikely to be high in comparison with the cost of development schemes for agriculture now being considered.

Losses of Rubber Instructors to plantation companies as well as to the R. I. (R.) B. coupled with the difficulty of securing qualified replacements has reinforced the need for a stronger cadre of Junior Rubber Instructors and the establishment for Junior Rubber Instructors was raised to thirtysix for 1956. From over 300 applicants for appointment twentytwo were selected for preliminary training during three months at the RRI Experiment Station and fifteen were appointed at the conclusion of the course. In addition three Rubber Demonstrators with exceptionally good records were promoted to Junior Rubber Instructor. Five Junior Rubber Instructors resigned during the year and there were thus only thirty in the Service at the end of the year.

The Rubber Demonstrator cadre was further reduced to nine by the three promotions noted above, by seven resignations and one dismissal. A boatman was appointed for the outboard motor boat used by our Junior Rubber Instructor, Dabong, on the Galas and Pergau rivers.

Considerable progress was made towards providing quarters for Rubber Instructors in those stations which have high priority for the services of a Rubber Instructor and where accommodation has been difficult to obtain. Two houses each have been completed and are in use in Seremban and Sungei Patani. At Muar, building of single house was well advanced at the end of the year and at Batu Pahat (2), Taiping (1), Machang (1) and Ipoh (1) building had commenced or contracts had been awarded. Plans for a house at Sitiawan are receiving consideration from the Town Board and at Malacca a possible site is under investigation. At Raub the State Forest Officer has been helpful in offering to excise a piece of forest reserve to provide a building site and this was under investigation at the end of the year. Only at Kuantan have efforts met with continual frustration. It now seems clear that we cannot hope to get a reasonably priced piece of land within the Kuantan Town Board area and our search is being extended to rural areas. At Dabong, a new village settlement in Ulu Kelantan, we have obtained a plot of land for a house for a Junior Rubber Instructor and by the end of the year the contract for a simple timber house had been awarded.

ADVISORY

Tapping

In many districts on the West coast, particularly in Malacca, Selangor, Negri Sembilan and Johore, replantings established prior to the Replanting Scheme have been reaching maturity in small but important amounts. Rubber Instructors have been giving such areas careful attention to try to ensure that trees are not tapped before they reach accepted standards of development, and that sound tapping methods are adopted from the beginning. At the same time information is being collected on yields obtained by smallholders from different planting materials and with varied systems of tapping. It is clear that as the larger areas of young rubber established under replanting and new planting schemes attain development approaching tappability, demands on the advisory service will be heavy if much of the effort of planting is not to be squandered by premature and excessive tapping of young trees.

For peasant planters the temptations to tap too early and too hard are apparent. Land under vigorous young rubber cannot provide any income from short term catch crops during the period after the rubber trees are three years old and, during the same period, there are no grant payments to assist smallholders. Although no portion of replanting grants could provide for subsistence during the period when the land must be unproductive, the holding of a proportion of the replanting grant, until trees reach accepted standards of tappability, would be appreciated by those responsible for advising smallholders on tapping. Such a delayed instalment would enable smallholders to provide good equipment for tapping and processing their crop.

Manufacture

Table 1 shows quantities of latex collected from smallholders either for manufacture of concentrated latex or of sheet rubber. The amount of latex collected for concentration shows a decline to about 60% of the 1955 figure and this decline was progressive throughout the year. A complementary swing to sheet manufacture by small central factories was apparent but this did not compensate fully for the decline in use of smallholders' latex for concentrate. Total purchase of latex from smallholders was approximately 90% of the 1955 amount. Rubber Instructors give constant attention to the possibilities of improving quality of smallholders' rubber by some degree of centralisation of processing.

TABLE 1. SMALLHOLDERS' RUBBER PROCESSED IN CENTRAL FACTORIES

State	Collected for sale as latex: tons dry rubber	Collected as latex & made into sheet rubber: tons dry rubber
Selangor	830	810
N. Sembilan	280	204
Malacca	18	12
Perak	289	271
Johore	1,158	1,409
Pahang	6	—
Kedah/Perlis	242	28
Penang/PW	—	—
Kelantan	—	—
Trengganu	—	—
<i>Total</i>	2,823	2,734

Planting of Rubber

The steady rise in amount of new planting is shown by the areas, 3360, 8050 and 13,055 acres which are our records for the years 1954, 1955 and 1956 respectively. These figures show the desire of States and peasants to press on with development of new areas despite delay in the formulation of plans for assisting new planting. When these are published there will no doubt be further large increases in new planting.

The distribution of new planting between the several territories is shown in Table 2. This follows the general pattern of the 1955 figures and again the major proportion (83%) of new planting is in plots of five acres and under. Only in Kedah is the area in lots of more than five acres notably higher than the average at 47%.

TABLE 2. NEW PLANTING DURING 1956

Territory	Total acres	Planted clonal seeds	Percentage clonal seedling	Budgrafting on new planting
Selangor	37	37	100	—
N. Sembilan	777	777	100	90
Malacca	62	62	100	2
Perak	3,209	2,969	93	344
Johore	597	113	19	179
Pahang	3,324	3,063	92	1,561
Kedah/Perlis	2,699	2,347	87	207
Penang/PW	8	3	37	68
Kelantan	1,388	1,215	88	78
Trengganu	954	712	75	—
<i>Total</i>	13,055	11,298	87	2,529

The proportion of new planting effected with clonal seedlings again shows an increase at 87% of the total and only in Trengganu have difficulties over supply of clonal seeds limited the amount of clonal seedling planting. In Johore, the low use of clonal seedlings on new plantings must be assumed to indicate a preference of cultivators for budgrafting. Total area budgrafted shows a small decline on the previous year's record. This is in keeping with requirements when allowance is made for clonal seedling planting. There appears however to be a growing appreciation of the merits of budgrafted trees amongst the most progressive smallholders which can be traced to experience in tapping young rubber areas. Instances of clonal seedlings being budgrafted are increasing.

Concern over the effects of root diseases on replantings continues but incidence of disease varies markedly between plantings. While further information on the effects of poisoning with 2,4,5-T on the rate of decay of roots is awaited, steps to minimise spread of disease depend on persuasion. The majority of areas continue to be prepared for replanting by felling trees at waist height leaving stumps and roots untreated in the soil.

Rubber Instructors have collaborated with Replanting Scheme staff in establishing trials of oil based herbicides for control ofalang in replantings. These trials have largely failed to achieve their purpose because they were initiated at a late stage in the dry seasons and because workers and supervisors have had inadequate experience in spraying technique. The trials have shown the need for further careful investigation of means of controllingalang.

INFORMATION

Increasing importance is attached to organised training for smallholders and we have aimed at using facilities wherever available to provide training covering a varied range of work at different levels.

At the R.R.I. Experiment Station a three months course of training was provided for prospective Junior Rubber Instructors and RIDA management trainees. Of the 30 who attended 15 were subsequently appointed Junior Rubber Instructor. Towards the end of the year, in the main planting season, three courses each of four weeks' duration were held for smallholders and 99 persons attended. Certificates were given to 74 trainees who had satisfactory results on tests and examinations.

At Batu Pahat our second long term training courses were completed by 26 Chinese and 12 Malays. Thirty passed the final examinations and obtained certificates. New courses for both Chinese and Malays were started at Batu Pahat during the year and continued into 1957.

The Chinese Rubber Instructor, Kinta, conducted a course for Chinese schoolboys at Sungei Durian New Village extending over twentyfive days. Of sixteen boys enrolled nine took the examination at the end of the course and seven obtained passes and were awarded certificates. A course started at Sitiawan for Chinese schoolboys had to be terminated because of the lack of interest.

Junior Rubber Instructors provided instruction on rubber subjects for trainees attending courses organised by the Department of Agriculture at Pekan, Pahang, and Ayer Ititam, Johore.

A site for our pilot instruction centre for smallholders was selected in the district of Alor Gajah, mukim of Ayer Pa'abas, and purchase negotiated during the first four months of the year. Clearance to build quarters and hostel accommodation on the area was obtained from the Settlement War Executive Committee. Difficulty was experienced in finding a contractor willing and able to undertake building in the traditional Malay style required. Plans for a hostel and Junior Rubber Instructor's house were worked out by Mr R. N. Hilton and executed by Mr Hoh Chu Chuan. A contract for building these was awarded in December. The area was fenced completely and a small budwood and seedling nursery established. Cover crops were planted throughout the area but in general these are not developing well. No tapping was done from April onwards when the holding came under our control. This training centre is expected to be in operation by the middle of 1957.

Our mobile cinema unit has continued to provide good assistance for Rubber Instructors in teaching smallholders. The unit was out on tour during 177 days and provided 140 film shows for kampong audiences. In addition it was used as required for screenings at the R.R.I. Experiment Station for instructional courses and at Batu Pahat. All territories with the exception of Malacca were visited by the unit.

The following publications were received from the printer during the year:

- Replanting on Smallholdings — Chinese edition;
- Replanting on Smallholdings — Malay (Jawi) edition;
- Root Disease Control — Malay (Jawi) edition (revised);
- Preparation and Planting of Clonal Seedling Stumps — Malay (Jawi) edition;
- Preparation and Planting of Clonal Seedling Stumps — Chinese edition;
- Manuring of Young Rubber — English edition;
- Manuring of Young Rubber — Chinese edition.

At the request of the Director of Agriculture, Sarawak, a Malay (Rumi) edition of 'Replanting on Smallholdings' was prepared and passed for printing. The Rumi script is of greater importance in the North Borneo territories than is Jawi and to meet our obligations to these countries it is likely that most of our publications should have a Rumi edition although this has limited application in this country.

Mr Greenwood completed the compilation of an illustrated manual on tapping entitled 'Good Tapping' and English, Jawi and Chinese editions were with the printer at the end of the year.

A new poster on budgrafting has been prepared in which coloured illustrations from our manual 'Budgrafting' have been used. An edition is in course of printing in which captions will be provided on separate copies in Rumi, Chinese and (at the request of the Director of Agriculture, Sarawak) Dayak. When these are available a Jawi edition will be printed with an appropriate arrangement of illustrations.

Pressure of other work has prevented the completion of editing of the film on root disease control. This indicates necessity of having a full time assistant with special training in film editing to undertake such work. It should be for consideration whether the requirements of other Divisions and Sections would justify an appointment of this nature.

INVESTIGATIONS

At the R.R.I. smallholding near Ampang, remaining old (pollarded) trees in the 1950 hedge planting were poisoned with 2,4,5-T between January and April. In the 1948 and 1949 hedge plantings the remaining 25% of the original stand was winched out in October and stumped buddings of RRIM 513 and 624 were planted in the centre of the space between hedges. In the 1950 area of stumped buddings of RRIM 501 planted at orthodox distances, 73 trees have been opened for tapping. In the 1948 hedge planting 110 clonal seedlings were brought into tapping. Twentynine trees were removed on girth and spacing in a further thinning round in the 1948 and 1949 hedges and in the 1950 hedges. These trees were killed by treating a 6 inches basal band with a 5% dilution of 2,4,5-T in diesel oil. It was noted that in twelve cases of buddings treated with 2,4,5-T adjacent buddings showed effects of the poison whereas in the seedling planting no effects to adjacent trees were noted.

The girth measurements for the samples of trees and increments during 12 months are shown below:

	<i>Dec. 1955 inches</i>	<i>Dec. 1956 inches</i>	<i>Increment inches</i>
1948 double rows 3ft x 4ft at 64ft	10.8	13.4	2.6
1948 double rows 4ft x 4ft at 64ft	12.9	14.6	1.7
1949 double rows 5ft x 6ft at 64ft	9.7	11.4	1.7
1950 single rows 4ft x 54ft	12.0	14.6	2.6

COSTS OF REPLANTING ON SMALLHOLDINGS

Records of operations and costs of five case studies of replanting on smallholdings were maintained.

PROCESSING AND MARKETING OF SMALLHOLDERS' RUBBER

Mr J. W. L. Bevan completed his report on the marketing of smallholders' rubber with special reference to the first buyer level and this was duplicated for limited distribution.

L. R. DAVIDSON
Smallholders' Advisory Officer

SENIOR STAFF AND GRADUATE ASSISTANTS

ADMINISTRATION

- C. E. T. Mann, M.Sc., F.I.R.I. *Director*. (First appointed 15 June 1927)
 C. G. Akhurst, B.Sc., A.R.C.S., A.I.C.T.A. *Deputy Director*. (First appointed 7 October 1930)
 H. S. Blacklin, Secretary. (First appointed 1 March 1932)
 J. C. Reeves, F.C.C.S., *Assistant Secretary*. (First appointed 11 September 1950)

PUBLICATIONS SECTION

- D. R. Rexworthy, B.Sc., F.R.I.C. *Publications and Information Officer*. (First appointed 23 July 1952)

STATISTICS SECTION

- D. R. Westgarth, M.Sc., *Statistician*. (First appointed 3 August 1950)
 Fong Chu Chai, B.Sc., Dip. Arts *Assistant Statistician*. (First appointed 8 July 1949)

EXPERIMENT STATION

- R. F. Harley, M.C., A.I.S.P. *Manager*. (First appointed 27 August 1937)
 A. E. Browne, M.C. *Assistant Manager*. (First appointed 1 February 1948)
 J. D. Macritchie, B.Sc. (Agri.). *Assistant*. (First appointed 15 December 1954)
 J. H. Chapman, B.Sc. (Agric.) *Assistant*. (First appointed 19 August 1955)

SOILS DIVISION

- G. Owen, M.Sc. *Head of Division*. On leave from 14 April to 11 November. (First appointed 5 January 1939)
 E. W. Bolle-Jones, M.Sc., Ph.D., M.I.Biol. *Plant Physiologist*. (First appointed 20 August 1952)
 G. M. F. Grundy, B.Sc. *Soils Chemist*. (First appointed 5 January 1953 after a year's study in Trinidad and England)
 G. A. Watson, Ph.D., A.R.C.S., A.R.I.C., D.I.C. *Soils Chemist*. (First appointed 17 November 1955)
 V. R. Mallikarjuneswara, B.Sc., M.Sc. *Assistant Soils Chemist*. (First appointed 4 April 1955)
 M. M. Guha, B.Sc., Assoc. I.A.R.I. *Assistant Soils Chemist*. (First appointed 20 May 1955)

BOTANICAL DIVISION

- E. D. C. Baptist, M.Sc., Ph.D., A.R.C.S., D.I.C. *Head of Division*. (First appointed 20 March 1935) Resigned 9 February.
 C. W. Brookson, B.Sc. *Botanist*. Acting Head of Division, 9 February; confirmed 1 June. (First appointed 23 August 1949)
 P. de Jonge, Agri. Ir. *Botanist*. (First appointed 29 December 1950)
 J. S. Lowe, Ph.D. *Plant Physiologist*. (First appointed 11 February 1953). Resigned 18 February
 P. R. Wycherley, Ph.D. *Botanist*. (First appointed 26 January 1953). On leave from 14 July
 T. V. Vaidyanathan, B.Agric. *Assistant Botanist*. (First appointed 1 May 1935)
 V. K. Bhaskaran Nair, M.Sc. *Assistant Botanist*. (First appointed 26 May 1952)

PATHOLOGICAL DIVISION

- A. Newsam, Ph.D. *Head of Division*. (First appointed 5 April 1947)
F. W. Hutchison, N.D.A., C.D.A. *Field Research Officer*. (First appointed 5 March 1948). On leave from 29 April
R. N. Hilton, M.A. *Pathologist*. (First appointed 7 September 1948)
R. A. Fox, B.Sc., B.Agr. *Microbiologist*. (First appointed 2 March 1954)
K. P. John, B.A. *Assistant Pathologist*. (First appointed 16 November 1936)
B. S. Rao, M.A., D.P.P. *Assistant Entomologist*. (First appointed 6 June 1952)

CHEMICAL DIVISION

- W. G. Wren, B.Sc., A.R.C.S., D.I.C., A.I.R.I. *Head of Division*. (First appointed 7 January 1950)
G. W. Drake, B.Sc., M.A. *Chemist*. (First appointed 8 March 1948)
W. A. Southorn, Ph.D., A.R.I.C. *Chemist*. (First appointed 18 November 1952) On leave from 6 April
J. E. Morris, B.Sc. *Chemist*. (First appointed 20 June 1952). On leave from 5 June
H. M. Edmondson, B.Sc. *Technologist*. (First appointed 28 August 1950)
R. S. Gale, B.Sc.(Chem. Eng.), A.C.G.I., A.M.I.Chem.E. *Chemical Engineer*. (First appointed 2 May 1951).
D. J. Graham, A.S.T.C. *Chemical Engineer*. (First appointed 31 March 1953)
D. H. Taysum, M.Sc., D.I.C. *Microbiologist*. (First appointed 13 September 1954)
B. C. Sekhar, B.Sc., M.S., A.R.I.C. *Chemist*. (First appointed 15 September 1949)
K. C. Sekar, B.A., A.I.R.I. *Assistant Chemist*. (First appointed 1 October 1928)
R. C. H. Hsia, B.Sc. *Assistant Chemist*. On study course in England (First appointed 2 January 1953)
S. J. Tata, B.Sc. *Assistant Chemist*. (First appointed 14 December 1953)
S. T. Sethu, B.E.(Chem). *Assistant Chemical Engineer*. (First appointed 1 September 1955)

SMALLHOLDERS' ADVISORY SERVICE

- L. R. Davidson, B.Sc.(Agric.) *Smallholders' Advisory Officer*. (First appointed 1 December 1940)
J. M. F. Greenwood, B.Sc.(Agric.) *Assistant Smallholders' Advisory Officer*. (First appointed 25 November 1948)
J. W. L. Bevan, B.Sc.(Agric.) *Assistant Smallholders' Advisory Officer*. Seconded to Joint Working Party until 31 May. (First appointed 12 November 1952). Resigned 6 March
Shamsuddin bin Yub Ahmad, B.Agric. *Assistant Smallholders' Advisory Officer*. (First appointed 1 May 1938)

BALANCE SHEET A

LIABILITIES			
		31.12.1956	As at 31.12.1955
SUNDRY CREDITORS	\$ c	\$ c	\$
Staff	45,143.97		
Merchants	271,453.11		
Miscellaneous	16,228.43		
Malayan Rubber Fund	<u>139,671.37</u>	472,496.88	165,149
STAFF CONTINGENCY RESERVE FUND			
As at 31 December 1955		330,000.00	330,000
RESERVE FOR GRATUITIES FOR EQUALISATION OF PROVIDENT FUND CONTRIBUTIONS	<u>27,719.64</u>		19,331
Less Investment of this reserve in the Post Office Savings Bank	<u>27,719.64</u>	—	19,331
EXCESS OF ASSETS OVER LIABILITIES			
As at 31 December 1955	3,736,326.11		
Less Refund to Malayan Rubber Fund	<u>526,814.00</u>		
	3,209,512.11		
Add Excess of Income over Expenditure			
Head Office	464,461.59		
Experiment Station	<u>225,169.92</u>		
	3,899,143.62		
Less Expenditure written off:-			
Laboratory Buildings			
Head Office	<u>13,742.93</u>	3,885,400.69	3,736,326

Carried forward

4,687,897.57

4,231,475

ASSETS		31.12.1956		As at 31.12.1955
LAND AND BUILDINGS		\$	c	\$
2¼ Mile Compound				
Land as at 31 December 1955	15,784.35			
198 and 200 Ampang Road:				
At nominal value	<u>2.00</u>	15,786.35		15,786
3rd Mile Compound				
Land as at 31 December 1955	31,440.35			
251, 253, 255, 257, 259 and 261 Ampang Road:				
At nominal value	<u>6.00</u>	31,446.35		31,446
3¼ Mile Compound				
Land as at 31 December 1955	27,582.50			
262, 264, 266, 268 and 270 Ampang Road:				
At nominal value	<u>5.00</u>	27,587.50		27,588
4th Mile Compound				
Land as at 31 December 1955	2,000.00			
73, 4th Mile Ampang Road:				
At nominal value	<u>1.00</u>	2,001.00		2,001
Eaton Road Compound				
Land as at 31 December 1955	17,147.08			
1, 3, 5 and 7 Eaton Road:				
At nominal value	<u>4.00</u>	17,151.08		17,151
Wickham Road & Ridley Close				
Land as at 31 December 1955	43,623.50			
Nine Bungalows:				
At nominal value	<u>9.00</u>	43,632.50		43,633
Ulu Klang				
Land as at 31 December 1955	7,705.00			
Workmen's Quarters,				
At nominal value	<u>1.00</u>	7,706.00		7,706
Ampang Road Laboratories				
Land as at 31 December 1955	19,526.00			
Buildings as at				
31 December 1955	\$13,743.93			
Less:				
Written off against excess of assets over liabilities	<u>13,742.93</u>			
	1.00			
Additions during year	<u>518.52</u>	<u>519.52</u>	20,045.52	33,270
Carried forward			<u>165,356.30</u>	<u>178,581</u>

		As at 31.12.1955
	\$ c	\$
Brought forward	4,687,897.57	4,231,475

Carried forward	4,687,897.57	4,231,475
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		31.12.1955	As at 31.12.1956
		\$ c	\$
	Brought forward	165,356.30	178,581
LAND & BUILDINGS (Contd.)			
Sungei Buloh Laboratories & Houses			
As at 31 December 1955			
At nominal value:			
Laboratories	1.00		
Houses	24.00	25.00	25
Land & Quarters for Rubber Instructors			
As at 31 December 1955	18,846.72		
Additions during year	96,378.30	115,225.02	18,846
Pilot Instruction Centre			
		13,917.11	—
PLANT & MACHINERY: At nominal value			
		1.00	1
FURNITURE			
Residential Houses, Kuala Lumpur			
At nominal value		1.00	1
Sungei Buloh			
At nominal value		1.00	1
Offices, Kuala Lumpur			
At nominal value		1.00	1
Library			
At nominal value		1.00	1
Laboratories			
At nominal value			
Kuala Lumpur	1.00		
Sungei Buloh	1.00	1.00	1
APPARATUS & GLASSWARE: At nominal value			
		1.00	1
MOTOR VEHICLES: At nominal value			
		1.00	1
WORKSHOPS: At nominal value			
		1.00	1
LIBRARY BOOKS & PERIODICALS: At nominal value			
		2.00	2
EXPERIMENT STATION DEVELOPMENT			
As at 31 December 1955	2,054,132.96		
Additions during the year	301,139.21	2,355,272.17	2,054,133
	Carried forward	2,649,806.60	2,251,596

		As at 31.12.1956
	\$ c	\$
Brought forward	4,687,897.57	4,231,475

REPORT OF THE AUDITORS TO THE BOARD OF THE RUBBER
RESEARCH INSTITUTE OF MALAYA

We have examined the above Balance Sheet with the books and vouchers of the Rubber Research Institute of Malaya and report that we have obtained all the information and explanations we have required.

Titles to certain of the Institute's Lands have not yet been issued.

Subject to the above, in our opinion, this Balance Sheet is properly drawn up so as to exhibit a true and correct view of the state of the Institute's affairs as at 31 December 1956 according to the best of our information and the explanations given to us and as shown by the books of the Institute.

Kuala Lumpur
20 March 1957

Sgd Peat, Marwick, Mitchell & Co.
Chartered Accountants
Auditors

\$4,687,897.57

\$4,231,475

				As at 31.12.1956
			\$ c	\$
		Brought forward	264,980.60	2,251,596
STOCKS				
Petrol, Oil & Chemicals				
	Head Office	278.80		
	Experiment Station	<u>8,954.81</u>	9,233.61	
Empty Containers & Drums				
	Head Office	217.00		
	Experiment Station	<u>2,160.00</u>	2,377.00	
Stationery				
	Head Office		7,335.18	
Sundry Materials				
	Head Office	14,252.91		
	Experiment Station	<u>16,387.04</u>	30,639.95	
Rubber				
	Experiment Station		65,070.93	114,656.67
SUNDRY DEPOSITS			170.00	78,332
SUNDRY DEBTORS				170
Staff				
	Loans for Motor Vehicle			
	Purchase	163,865.62		
	Travelling & Sundries	<u>20,325.48</u>	184,191.10	
General				
	Head Office	159,414.20		
	Experiment Station	<u>10,983.37</u>	170,397.57	
Interest Accrued on Investments			6,382.99	
Payments in Advance				
	Head Office	5,989.34		
	Experiment Station	<u>8,357.45</u>	14,346.79	375,318.45
LOCAL AND BRITISH GOVERNMENT SECURITIES				357,814
(Held for account of Staff Contingency Reserve Fund)				
\$ 15,000	4½% Singapore Municipal Debenture Stock 1930-70/80 (\$17,537*) (\$13,687†)		15,000.00	15,000
\$ 40,000	3% F.M.S. Government War Loan 1940-52/59 (\$40,000*) (\$37,400†)		40,000.00	40,000
\$160,000	3% Malayan Union Government Loan 1946-62/66 (\$160,000*) (\$133,796†)		160,000.00	160,000
£ 20,600	3½% British War Loan 1952 (\$145,322*) (\$123,090†)		145,322.05	145,322
* Original Cost — \$362,859				
† Market value as at 31 December 1956 — \$307,973				
CASH AT BANK AND IN HAND				
At Bank				
	Fixed Deposit	504,375.00		
	Current Account	678,580.50		
In Hand		<u>4,668.30</u>	1,187,623.80	1,183,241
			<u>\$4,687,897.57</u>	<u>\$4,231,475</u>

Income & Expenditure Account (excluding Experiment

To	EXPENDITURE	31.12.1956	As at 31.12.1955
		\$ c	\$
International Rubber Research Board/International			
Rubber Development Committee		4,464.32	6,103
London Advisory Committee		22,194.19	21,648
Board Meetings		2,636.67	4,049
Salaries of Staff on Agreement		508,703.11	465,299
Salaries of Staff not on Agreement		1,011,875.63	855,372
Provident Fund		170,386.94	139,248
Medical		20,986.74	18,369
Travelling		63,648.09	70,389
Office General Charges		37,053.80	34,610
Rent, Rates & Taxes		13,250.90	13,057
Insurance		27,291.22	24,189
Laboratory General Charges		7,729.46	6,095
Buildings & Grounds		148,408.95	48,126
Furniture & Office Equipment		71,671.21	20,820
Fixtures & Fittings		31,217.80	11,578
Plant & Machinery		108,578.24	70,194
Vehicle		11,977.94	11,327
Workshop		26,117.32	8,124
Apparatus & Glassware		155,117.33	78,902
Laboratory Chemicals		24,060.10	22,382
Publications		20,724.25	18,373
Library (Books & Periodicals)		15,229.66	11,881
Exhibitions		7,405.74	3,807
Smallholders' Advisory Service		568,112.78	613,178
Field & Factory Experiments		64,694.28	68,806
Technical Classification		22,340.31	26,814
Gratuities to Staff		20,000.00	26,336
Leave Pay		101,974.15	132,282
Passages		40,108.13	51,529
Grant towards Passages		3,852.75	890
		<u>3,331,812.01</u>	<u>2,883,777</u>
Excess of Income over Expenditure for the year		464,461.59	546,929
		<u>3,796,273.60</u>	<u>3,430,706</u>

Income & Expenditure Account for Experiment

To	EXPENDITURE	\$ c	\$
Revenue Expenditure		712,447.28	622,128
Excess of Income over Expenditure for the year		225,169.92	492,956
		<u>937,617.20</u>	<u>1,115,084</u>

Station) for the year ended 31 December 1956

By	INCOME	31.12.1956	As at 31.12.1955
		\$ c	\$
Contributions received from the Malayan Rubber Fund		3,707,426.00	3,356,426
Publications sold		9,883.31	7,614
Rents on Houses		17,712.27	21,245
Interest on Loans		2,161.82	2,769
Interest on Investments		26,560.39	13,333
Miscellaneous		32,529.81	29,319
		<u>3,796,273.60</u>	<u>3,430,706</u>

Station for the year ended 31 December 1956

By	INCOME	\$ c	\$
Sales & Stock of Rubber		827,441.89	1,041,052
Sales of Planting Materials		37,813.04	21,567
Miscellaneous		165.50	163
Rubber Industry (Replanting) Board			
Refund on account of Replanting Cesses		51,247.33	
Refund on account of Anti-Inflationary Cesses		10,874.44	52,302
Government Rubber Replanting Scheme for Estates			
Grant under the Government Scheme for the year 1955		10,075.00	—
		<u>937,617.20</u>	<u>1,115,084</u>

